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Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages and it should be exclusive to this journal. A copy of the article in floppy/CD may also be provided. Illustrations should be drawn with pen and indelible ink. Photographs (black and white) at least of postcard size, should be on glossy paper and should be properly packed to avoid damage in transit.

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CONSTITUTION OF INDIA

Preamble

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

Acc no-15999

The Fascinating Chemistry of Fireworks

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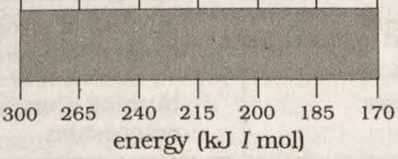
Have you ever been to an aerial fireworks show on any celebration or have seen it on TV channels and wondered about how all the impressive colours and sounds are produced? People everywhere enjoy the fantastic display of and the brilliant lights of fireworks. However, these spectacles are much more than just a form of entertainment. Each firework is a precisely formed assembly of chemicals and fuel, carefully calibrated to produce a particular effect — a red chrysanthemum spray accompanied by a powerful explosion, or a blue strobe, for example. Understanding how the contents of a firework produce the impressive variety of colours, forms, and sound intensities requires only a simple understanding of chemical reactions. This method of learning chemistry concepts with real life situations becomes more meaningful and joyful. The understanding also becomes clear and retention is longer.

Fireworks generate three very noticeable forms of energy: a tremendous release of sound, bright light, and heat. The tremendous booms heard at ground level are the result of the rapid release of energy into the air, causing the air to expand faster than the speed of sound. This produces a shock wave, a sonic boom.

The colours are produced by heating metal salts, such as calcium chloride or sodium nitrate, that emit characteristic colours. The atoms of each element absorb energy and release it as light of specific colours. The energy absorbed by an atom rearranges its electrons from their lowest-energy state, called the ground state, up to a higher-energy state, called an excited state. The excess energy of the excited state is emitted as light, as the electrons descend to lower-energy states, and ultimately, the ground state. The amount of energy emitted is characteristic of the element, and the amount of energy determines the colour of the light emitted. For example, when sodium nitrate is heated, the electrons of the sodium atoms absorb heat energy and become excited. This high-energy excited state does not last for long, and the excited electrons of the sodium atom quickly release their energy, about 200 kj mol, which is the energy of yellow light.

The amount of energy released, which varies from element to element, is characterised by a particular wavelength of light. Higher energies correspond to shorter wavelength light, whose characteristic colours are located in the violet/blue region of the visible spectrum. Lower energies correspond to longer wavelength light, at the orange/red end of the spectrum.



The colours you see exploding in the sky are produced by the elements with the characteristic emissions listed in the table below.

In making fireworks, the metal salts are put into stars, small clay or dough-like lumps or cubes 3 to 4 cm in diameter. Stars consist of a blend of oxidising agent, reducing agent, colouring agent (metal salt), and binders. When ignited, the stars produce both sound and light effects. The appearance of a firework is determined by its stars, which are made by hand and carefully packed into cardboard compartments within the firework shell, where they await ignition by a time-delay fuse.

From lift-off to colour release, a carefully choreographed sequence of events takes place, producing the desired effect. The power needed to lift each firework into the air is provided by the highly exothermic combustion of black powder, a slow-burning combination of 75% potassium nitrate, 15% charcoal, and 10% sulfur. Said to have first been used in China about 1000 years ago, the recipe for black (or coal) powder has undergone little change since then. This formulation explodes at a rate of about 3 metres per second, classifying it as a low explosive. In fact, when it burns in the open air, black powder's heat and gas dissipate quickly. The key to fireworks'

Colour	*Compound*	*Wavelength (nm)*
Red	strontium salts, lithium salts lithium carbonate, Li_2CO_3 = red strontium carbonate, $SrCO_3$ = bright red	652
Orange	calcium salts calcium chloride, $CaCl_2$	668
Yellow	sodium salts sodium chloride, NaCl	610-621
Green	barium compounds + chlorine producer barium chloride, $BaCl_2$	589
Blue	copper compounds + chlorine producer copper(I) chloride, CuCl	505-535
Purple	mixture of strontium (red) and copper (blue) compounds	420-460
Silver	burning aluminum, titanium, or magnesium	

success is to trap the heat and gas in the bottom of the shell, which is positioned in a launch tube or mortar, until the trapped gas pressure builds to such a force that, when it escapes, it hurls the firework high into the air.

A firework is ignited by lighting the main fuse. That simultaneously starts both the fast action fuse, which quickly carries the flame down to the lift charge, and the time delay fuse, which continues to burn upward toward the cardboard compartments containing the stars, even as the firework is hurtling skyward.

Fireworks are classified as both a low and a high explosive. The initial lift charge that sends the firework into the sky is a low explosive. The burning charge undergoes rapid decomposition, but not detonation. The firework can be thought of as flying through the air powered by a fast burning wick. Where the wick ends, it meets the high explosive components of the firework. In this second stage there is an instantaneous detonation producing both a loud explosion and a bright flash of colour.

The black powder lift-charge is calculated to exhaust itself precisely when the slow-burning, time-delay fuse reaches the first compartment packed with lightproducing stars and black powder. This happens when the firework is at the very apex of its upward flight. Simultaneously the fuse sets off sound-producing explosives and detonates the stars, initiating colour emission. If the timing of the fuses is off, however, the firework may detonate early, too close to the ground, or late, when the firework is falling back to earth.

Chemistry of Fireworks

The sights and sounds of each explosion are the result of several chemical reactions — oxidations and reductions — taking place within the firework as it ascends into the sky. Oxidisers produce the oxygen gas required to burn the mixture of reducing agents and to excite the atoms of the light-emitting compounds. Various oxidisers are used in both the black powder and the stars. The most commonly used oxidisers are nitrates, chlorates, and perchlorates. The reducing agents, sulfur and carbon, combine with the oxygen form the oxidisers to produce the energy of the explosion.

The most commonly used oxidisers are nitrates, the major component of black powder. Nitrates are composed of nitrate ions (NO_3) with metal ions. The most common oxidiser is potassium nitrate, which decomposes to potassium oxide, nitrogen gas, an d oxygen gas.

$$4KNO_3 \rightarrow 2K_2O + 2N_2 + 5O_2$$

When reacting, nitrates release two of their three oxygen atoms. Because the oxidation does not result in the release of all available oxygen, the reaction is not as vigorous as that of other oxidizers and is more controlled. This is why nitrates are used as the major component of black powder. In fireworks their main purpose is to provide the initial thrust to power the package into the sky and to ignite each bundle of stars. Nitrates are usually not used in star explosions, because reactions of nitrates do not produce a temperature high enough to energize many of the more colourful metal salts.

In the 1830s Italian fireworks makers found a group of more explosive oxidizers, which produced temperatures of 1700 to 2000°C and made possible the creation of much more intense colours. These oxidisers are the chlorates, which contain the chlorate ion (ClO_3), and they give up all their oxygen upon reaction.

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

This results in a much more intense and spectacular reaction.

These chlorates have the disadvantage of being less stable mechanically than nitrates, and therefore more dangerous to handle. Chlorate compounds sometimes can be detonated just by dropping them on the ground! This instability results from the fact that although the chlorine atom has the potential to bond with four oxygen atoms, in chlorates it bonds with only three, leaving the chlorine atom unsaturated and reactive. The complete release of its oxygen atoms makes chlorate a better oxidising agent than nitrate. Unlike nitrate-containing compounds that produce a relatively slow burning rate, the oxidation by chlorates produces a much faster detonation — an explosion. In recent years, fewer fireworks manufacturers are using chlorates. Instead, perchlorates are now more commonly used because of their increased stability and oxygen release.

Perchlorates contain the perchlorate ion (Cl04–), in which each chlorine atom is bonded to four oxygen atoms. The chlorine is bonded to its maximum number of oxygen atoms, and so perchlorates are more stable than chlorates. Yet, perchlorate is able to release all four of its oxygen atoms.

$$KClO_4 \rightarrow KCl + 2O_2$$

So, perchlorates are not only more stable, but more oxygen-rich than chlorates. They, like chlorates, produce more vigorous reactions than nitrates.

The oxygen released by nitrates, chlorates, and perchlorates in the star compartments immediately combines with the reducing agents to produce hot, rapidly expanding gasses. The most common reducing agents are sulfur and carbon (charcoal) — standard components of black powder — which react with oxygen to produce sulfur dioxide and carbon dioxide respectively:

$$O_2\,(g) + S\,(s) \rightarrow SO_2\,(g)$$

$$O_2\,(g) + C\,(s) \rightarrow CO_2\,(g)$$

The reactions that produce these gases also release a great deal of heat energy, so not only are the gases produced rapidly, they are hot and rapidly expanding gases. This adds to the explosive force of the reaction.

Firework Safety

Fireworks are used so frequently today in celebrations that it is easy to forget that they are dangerous explosives. Every year several people suffer injuries caused by the personal use of fireworks. Many of the victims are children. Some of the injuries are caused by illegally obtained fireworks, and burns account for half the injuries. (An ordinary sparkler burns at a temperature of more than 1000°C!)

The government enforces stringent safety regulations for fireworks manufacture, sale and displays. Spectators must keep well away from the launch area. Shells may not be launched if winds are stronger, because they could be blown off course. Nevertheless, many accidents occur with unregulated, informal neighborhood displays, when spectators attracted to the activities stand dangerously close to the launch area.

Fireworks manufacturers also go to great lengths to ensure safety, but even so, many workers were killed in firework plants. Safety regulations require that buildings be separated by concrete blast walls and that roofs be weakened to ensure that any explosion travels upwards rather than outwards. In addition, most fireworks are still made by hand because metal machinery could produce sparks or static electricity which would ignite the explosives.

Origins of Black Powder

Gunpowder or black powder was invented in China by alchemists experimenting with a naturally-occurring salt, potassium nitrate, also known as saltpetre. Ironically, they were looking for an elixir of immortality. But in handling and heating the sensitive substance they inevitably discovered its explosive properties. The first known account of the use of gunpowder as a weapon dates to 1046 in China, describing a catapult-launched grenade, an incendiary bomb, and a smoke bomb. The Song Dynasty Emperor in 1067 banned the sale of saltpeter and sulfur to foreigners and nationalised the production of gunpowder.

Marco Polo is sometimes given credit for bringing gunpowder to Europe but that is unlikely. When Europeans invaded the Middle East during the Crusades, they encountered gunpowder weapons used by Moslem forces. Despite government control and attempts to keep the formula secret, gunpowder probably travelled the Silk Road from China to the Moslem world far earlier than Marco Polo's trip in the late 1200s. English philosopher Roger Bacon (1217-1292) is believed to the first Westemer to describe gunpowder and fireworks. By the mid 1300s, European armies were using crude cannons and other gunpowder weapons.

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Calcium Crisis : Overcome It

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CALCIUM IS key to keeping body running smoothly. Our need for calcium starts even before we are born and extends throughout lifetime. Women need far more calcium than their male counterparts. The survey of the eating habits of Indians confirms that teenagers, young women and post-menopausal women in particular are consuming far less calcium than their body's requirement. Women are much prone to lose calcium and are more disadvantaged. As compared to men they start with less bone mass. No matter what age a woman is when she becomes pregnant, calcium is very important to both the mother and the baby. Calcium from mother's body is used by the developing fetus, putting increased demands on the mother's supply. During pregnancy there is increase in the demand of calcium by the growing fetus to the extent of 28 gm, 2/3rd of which is required in the last trimester. Depletion of calcium, if any, results in hyperplasis of the parathyroid gland of the mother. To protect maternal skeletal calcium, thyroid gland secretes more of calcitonin hormone during pregnancy. Pregnancy-induced high blood pressure is a common serious complication that can put both mother and child at risk. According to report published in the Journal of American Medical Association (JAMA) there is evidence that increasing calcium intake can help maintain normal blood pressure in pregnant women. During lactation this extra demand for calcium continues. Breast feeding does not jeopardise a woman's overall health, provided her diet supplies adequate calcium. As a woman crosses 30, she starts losing bone mass at the rate of one per cent every decade. When a woman enters menopause, the production of estrogen by ovaries drops dramatically. Normally, estrogen maintains a balance between bone building and bone excavating cells. Loss of this magic hormone disturbs this balance and leads to reduction in calcium absorption. After menopause, when the body produces less estrogen, women lose 2.5 per cent of bone mass per year for about five years after which it continues at slower rate.

Of about two dozen minerals required by the body, calcium is the most important. It constitutes about 3 per cent of the body weight in an adult, with total calcium content varying from 900-1500 gm. About 99 per cent of this amount is in the bones. Only 9-10 milligrams of calcium circulates in 100 mililitres of blood. Calcium is present in blood/plasma in three different forms. About 40 per cent calcium is bound to plasma protein, albumin. Ten per cent of calcium is diffusible. Fifty per cent of calcium is both diffusible and ionized. This ionic calcium does most of the functions of calcium in the body. Two tiny glands above the thyroid in the neck, called parathyroid glands, regulate dynamic equilibrium of calcium between blood and bones. Though a minute amount of calcium circulates in the blood stream to permeate the entire system-complex of the body, it has a vital role to play for almost all life-processes of the body. All the neuro-muscular functions, the formation of body enzymes, the coagulation of blood to seal a bleeding wound and the formation and maintenance of bones and teeth depend upon the adequate amount of available calcium in one's blood and body. If body does not get enough calcium from daily diet, then body 'steels' the calcium from bones to make up the difference. Calcium requirement depends on number of factors: sex, age, physical activity and your body addiction, if any. The following are the recommendations of ICMR on calcium intake per day.

Status	*Calcium Required (mg)*
Adolescent/Puberty	500-600
Adult	400
Pregnant women	1000
Lactating women	1000
Pre-menopause	1000
Post-menopause	1000

American standards are higher, i.e. 800 mg/day for adults because meat, salt, tobacco and physical inactivity leads to rapid calcium loss. Doctors think that regular intake of milk may not provide crucial 1000 mg of calcium required by woman during critical phases of her life. One glass of milk gives you only 316 mg of calcium. A small cup of non-fat yoghurt contains 244 mg of calcium. Most women rarely have both a day. Even if they do, it takes care of barely 55 per cent of calcium intake. The rest, experts say, can come from a glass of orange juice (330 mg), dried figs (286 mg), and English muffins (98 mg). Furthermore, preliminary findings of the US researchers indicate that post-menopausal women who ate broccoli at least three times a week over one year were 80 per cent less likely to fracture a hip than those who consumed broccoli less than once a week. For best calcium absorption, it is advisable to eat foods which contain a calcium/phosphorus in the ratio of 2 : 1. Sea foods and green leafy vegetables have this magic ratio of 2 : 1 whereas in milk this ratio is 1 : 1, not very good for calcium absorption.

Teenagers who want to maintain hourglass figure, are on a very low calories diet and so are at a risk of having weak bones. In addition, today's teenagers have a stressful and sedentary lifestyle, therefore, care should be taken to provide suitable calcium supplements to them. While it is preferable to obtain the calcium one needs from one's diet, supplements may be of help, if one finds it difficult to get enough from food. Calcium supplements come in various forms and concentrations. The myrid forms of calcium include: calcium carbonate, calcium ornate, calcium malate, calcium citrate and calcium succinate. Each chemical form contains a different amount of 'pure calcium'.

Tips for Calcium Supplements

- Take calcium supplement with the meals as taking it at mealtime is a convenient way to remember its intake. After you have eaten, the stomach generates more acid, which helps in dissolving the tablet.

- As our body can absorb only small quantity at one time, take the supplement in divided doses, i.e. 2-3 times a day.
- Calcium citrate and malate are better than other calcium salts. However, the best absorbed form of calcium is micro crystalline hydroxyapatite concentrate (MCHC). It has calcium, magnesium, zinc, silica, maganese proteins and organic factors, all in a very well absorbed and non-toxic form.
- Vitamin D helps body to absorb and use calcium. It is good if we take vitamin D with calcium supplement.
- If you have had kidney stones in the past, you shouldn't take a calcium supplement without medical advice.
- Large doses of the less readily absorbed calcium supplements can lead to constipation, excess gas and bloating in some people.
- According to Tucker's research presented at the Annual meeting of the American Society for Bone and Mineral Research in Minneapolis, phosphoric acid in cola drinks binds to the calcium in the gut and thereby prevents its absorption. Therefore, avoid excess of fizzy drinks.
- Care should be taken while eating foods rich in phytates and oxalates because these chemical bind calcium making it less available for absorption.
- Among non-vegetarians chances of consumption of excess of proteins are greater. This leads to more urinary calcium excretion. Remember that coupling of meat intake with alcohol further increases calcium excretion in urine.

Researchers have found that calcium by itself prevents some bone loss after menopause. In addition, it definitely helps estrogen replacement therapy to work more effectively. To make hormone replacement therapy and other osteoporosis preventing medications work more effectively. The National Osteoporosis Foundation has made it mandatory for women to get adequate daily calcium intake.

Don't think of bones as rigid and lifeless support structures. They are composed of living cells embedded in hard framework of minerals. In fact, they are alive and very active organs of our body with a soft core called the marrow. Furthermore, they are not inert stockpiles of calcium. It is easy to visualize them, if you think of skeleton as a bank account, where deposits and withdrawals are available on day to day basis. Just as money is vital to bank account, calcium intake, storage and removal are critical for our bones. The bone is made up of a microscopic matrix framework, blood vessels, living cells and mineral deposit. The organic framework consists of collagen fibres, in a mesh, which give tensile strength and some flexibility to the bone. Minerals such as calcium, magnesium and phosphorous along with traces of manganese, zinc, chromium, sodium, potassium and iron are deposited in dense crystal attached to the matrix. The major salt of bone is hydroxypatite. Its crystals give bone its hardness, lending support and shape to the body and provide protection to delicate nerves and organ tissues. The bone cells, which are enclosed inside these hard mineral crystals, are active in nourishing the bone and its remodelling. Remodelling is a process of constantly dissolving and rebuilding of mineral deposits and is carried out by osteoblasts and osteoclasts. Bone is laid down in concentric circles called lamellae on the inner surface of osteoblasts. Osteoclasts, the phagocytic cells secrete proteolytic enzymes and eat away the bone by forming a small tunnel. Continuous remodelling helps in adjusting bone strength in proportion to degree of bone stress. Bone is deposited in proportion to the compressional load that the bone must carry, e.g. bones of athletes become considerably heavier than non athletes. Continuous physical stress stimulates calcification. Under normal circumstances, the bone building equals the dissolving. However, as we age, the rebuilding slows and some bone loss occurs. It there is accelerated bone loss, it leads to a condition called osteoporosis, meaning porous bones. Bone loss is associated with reduction in bone mass. In general, after 30, the bone mass gradually decreases. Risk factors for this disease include: old age, history of maternal hip fractures, menopause, small body frame, long-term steroid medication, being sedentary and lack of calcium in diet. Furthermore, chances of this disease are enhanced if you are suffering from chronic intestinal disorder, your periods have had a long break for reasons other than pregnancy or nursing; you have had a surgery for removal of your ovaries, you are smoker and alcoholic, you have hormonal deficiency of estrogen, you are Caucasian or Asian or you take corticosteroids to treat ailments like asthma, arthritis or cancer. This disease is characterised by reduced bone density causing structural deterioration of bone tissue, which leads to diminished physical strength of skeleton and increased susceptibility to fractures. Osteoporosis affects the whole skeleton. However, frequently affected sites include: distal radius, spine and the hip. Distal radius fractures normally heal well, but multiple spinal fractures may lead to a hunched back. Hip fractures are more devastating, leading of significant morbidity and even mortality. Osteoporosis is responsible for over one million bone fractures each year. Simple actions like bending to pick up a book or banging against a kitchen drawer, firm handshake and even sneezing cause breaking of bones. This disease kills more women each year than breast and uterine cancer put together. Today, approximately over six crore Indians are estimated to have osteoporosis of which 70 per cent are women. Worldwide 50 per cent of women and 20 per cent of men over the age of 65 suffer from this disease. This disease affects one in three women and one in 12 men at some time in their life. According to WHO, osteoporosis affects 30 per cent of all women after menopause. The depletion of estrogen due to menopause not only causes osteoporosis leading to hump, chronic pain, fracture and disability but also triggers coronary heart disease, Alzheimer's disease and an inability to think and make decisions. There is a strong link between thin bones and poor verbal memory. By the time women reach their 80th birthday, 40 per cent will have suffered a fracture of their spine. Indian men due to their genetic predisposition and lifestyle run a far greater risk of developing osteoporosis than their American counterparts. Yet, despite these disturbing statistics osteoporosis in Indian men remains under-diagnosed, under-reported and inadequately researched. Osteopororsis is responsible for the highest rate of morbidity and mortality – 25 per cent of the patients die within 12 months and at least 50 per cent are eventually unable to even walk independently. Therefore, an early detection of an osteoporosic state is quite important because subsequent precautions can be taken to minimise the incidence of fractures.

It is wrong to call osteoporosis an old woman's disease because more women in their late 30s and early 40s are falling prey to this debilitating disease. Our bones are forming and growing from birth until about age 18. In fact, the calcium which is provided to the bones when the person is very young determines how well the bones will hold up this precious mineral later in life. The best time to think about protecting yourself from this dreaded disease is when you are in 20s and 30s. But some researchers are now calling osteoporosis a paediatric condition because of the necessity of obtaining a high peak bone mass when one is very young to prevent osteoporosis in later years. Recent studies have emphasised the importance of ensuring optimal peak bone development prior to age of 20-30 in children and adolescent. During childhood and adolescence there is a rapid linear and appositional growth of the bones, the former reaches a maximum in the latter half of the second decade of life. Adolescence is the crucial period for bone health because an average woman gains 40-60 per cent of her bone mass during this period. In other words, your bone bank account should be padded during this very period for your retirement withdrawals! Bone mass then continues to increase by appositional growth and peak bone mass is attained during third decade of life. Age-related bone loss probably commences during the fourth decade and continues throughout life.

Unlike the rest of our body which groans and protests every time it is not feeling good, your skeleton sends no warning signals till it is too late. Osteoporosis progresses silently and painlessly until the bones become so brittle that even routine activities like coughing and sneezing can trigger a fracture and has been rightly called silent epidemic. Orthopaedician often calls osteoporosis 'silent thief' as it robs the body of its bone mutely and the sufferer has no inkling of it. Osteoporosis is a chronic disease and ignorance about it, whether on your part or your doctor, is a huge risk. Instead of waiting for the first twinge of pain in your back or a hairline hip fracture to make its appearance, act promptly just now and prevent this 'silent thief' from depleting your bone bank balance. Early detection of risk of osteoporosis can help determine the rate of bone loss, predict your fracture risk in future, and monitor the effects of treatment over a period of time. Worldwide, bone scan is the gold standard for detecting bone softening and measuring bone mass density. This would indicate the extent of your susceptibility to osteoporosis. Bone density assessment can be done by various methods: X-ray densitometry, Ultrasound densitometry and DEXA bone densitometry. X-ray densitometry is the cheapest option but it is not considered very reliable. In Ultrasound densitometry, sound waves are employed to measure bone density. It is widely used as a screening tool. It is slightly more reliable than X-ray densitometry. DEXA scan is a painless, non-invasive test for evaluating bone density. It exposes a patient to minimal radiation. The test lasts only a few minutes and requires a special machine and is very safe. All you are required to do is lie back on a comfortable padded table, breathe normally and have the scanner move over you. There is no discomfort. The scan cost between Rs. 2000-3000. This test is available in reputed hospitals and labs. Your report will consist of bone density measurements for each site scanned, a comparison of your data with an extensive data base of young normal bone density values and also a comparison of your results with a database of women/men of your age. The radiologist will use this information to assess your bone status and diagnose the degree of osteopenia. If you are found to be at risk for osteoporosis, your doctor will suggest several preventive measures, which include calcium rich diet, or calcium supplements; vitamin D, regular weight-bearing exercise, hormone replacement therapy for post-menopausal women, regular sleep, and one of several new drug therapies that have been shown to be clinically effective in slowing down or arresting calcium loss. A follow-up scans, usually performed at six-month intervals can help assess treatment effectiveness. When you go for this scan, make sure that you are not wearing belt or any cloth that has metal accessories or fastenings at the waist or hip level or unnecessary jewellery. As prevention is better than cure, bone scan is the best option for preventing osteoporosis by taking corrective steps in time.

Superconductivity and its Applications

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THE LIQUIFACTION of helium in 1908 by H.K. Onnes was the first milestone in the direction of superconductivity. Superconductivity is the phenomenon of zero electrical resistance exhibited by a material at and below a temperature called critical temperature (T_c) or it is a phenomenon wherein the resistance drops by many orders of magnitude to be vanishingly small (< 10^{-9} ohm) as the material cooled down. In 1911, H.K. Onnes found that mercury becomes superconducting at a temperature of 4.2 K[1]. Later on, a large number and variety of chemical compounds were found to superconduct at ambient or under high pressures. The value of T_c = 24 K for Nb_3 Ge remained a record until 1986 when a major break-through in the field of superconductivity was reported by Bednorz and Muller. They detected the appearance of super conductivity in ceramic oxide La – Ba – Cu – O with T_c = 30.4K[6]. In February 1987, the existence of high T_c oxide superconductor Y-Ba-Cu-O with T_c = 90K was reported by Wu et al [7]. The next significant discovery was made in early 1988 by Maeda et al [8]. They found T_c = 110K in Bi-Sr-Ca-Cu-O oxide system. Sheng & Herman reported T_c as high as 125K for Tl-Ba-Ca-Cu-O material [9]. Schilling et al have discovered superconductivity in Hg-Ba-Cu-O system with T_c =150K in 1993. In 1994, superconductivity (T_c = 250K) in $HgBa_2 Ca_{n1} Cu_n O_{2n+2\delta}$ (1223 or 1245) by J.L. Tholence [10] was reported. Another group led by M. Lagues has reported superconducivity with T_c = 250K in eight layers of BiO-Sr-Ca-Clu-O thin films. Han et al have reported the possibility of superconductivity above 250K in $Tl_{1.8}Ba_{2.0}G_{2.6}\ Cu_2O_{10+5}$ at very high pressure. However, these groups were not able to reproduce their experimental results. Fig. 1 depicts the chronological developments of T_c [1-16]. Table 1 depicts the name of known superconducting materials. Although the high T_c superconductors have been the focus of research on superconducting materials during the past decade, a large number of other noteworthy novel superconducting materials have been discovered during this period. Alkali metal doped with C_{60} reported by Bebard et al, is one of them [13]. Superconductivity and superconducting materials (high T_c superconductors have been included in the curriculum of physics at =2 level in the school education. It has been realised during internship programme of BSc.BEd. and BEd. students in different schools that there exists hardly any knowledge regarding the properties and potential applications of high T_c superconductors. Keeping aforesaid in view present article has been written with the following objectives:

- to define superconductivity and to classify superconductors;

- to imbibe the learners regarding signature and experimental features of superconductivity and superconducting materials;
- to discuss theoretical considerations, accounted for superconductivity; and
- to make learners aware about the methodology of synthesis and characterisation technique of superconducting materials including potential technological applications.

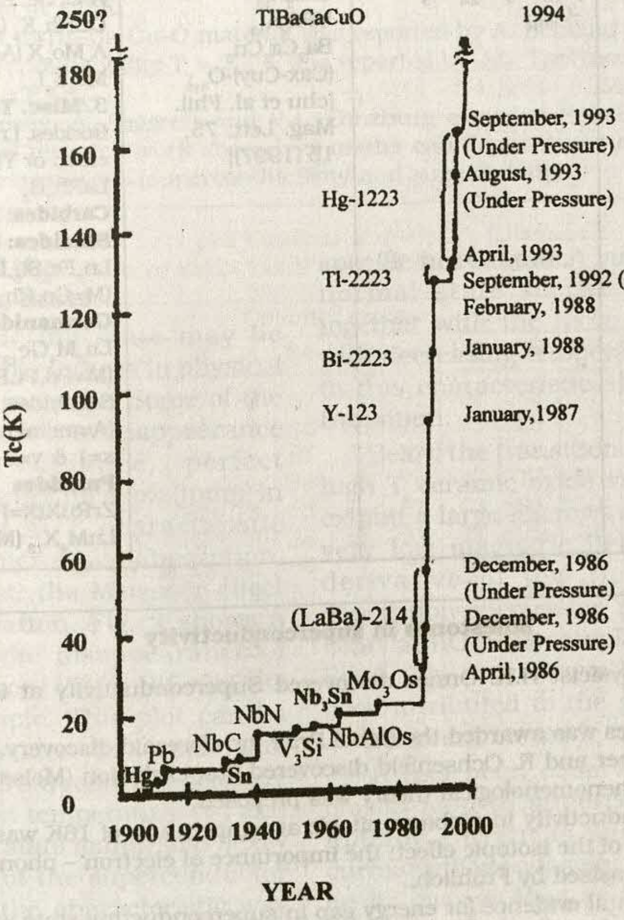

Fig.1 : Transition temperature (T_c) Vs Year

Table 1 : List of Superconducting materials [1-16]

Elements and Alloys	*High T_c(>77K)*	*$LuNi_2B_2C$*	*Ternary Systems*
Hg, Sn, Pb, Y, Nb, Mo, Nb-Ti **Intermetalics and compounds** 1. NbN, NbC, TaC, 2. Nb_3Sn V_3Si, Mo_3Os 3. ZrV_2, $CaRu_2$ 4. $La2C_3$, $(YTh)_{2-}C_3$ 5. PdH_x, NbH_x 6. MoN **Binary compounds** NbO, NbX_2, TaX_2(X-S,Se) La_3S_4, Zr_3S_4 Graphite Intercalated compounds (K_xC) **Organics and misc.** $(TMTSeF)_2X$ ($X=PF_6$, ClO_4) $(BEDT - TTF)_2I_3$, (SN)x **Fullerene solid** C_{60} intercalated with K, Rb, and Tl	Ceramic oxides $LnBa_2Cu_3O_7$ BiSrCaCuO TlBaCaCuO PbXrCaLnCuO HgBaCuO HgBaCaCuO BioSrCaCuO $Tl_{1.8}Ba_2Ca_{2.6}Cu_3$ $-O_{10+\delta}$	YPD_5B_3C Sr_2RuO_4 LiV_2O_4 $(Sr,Ca)_{14}Cu_{24}O_4$ $CeCu_2Si_2$ UBe_{13} UPt_3 $URuSi_2$ UNi_2A_{13} UPd_2A_{13} $Ba_2Ca_2Cu_3$ $(Cax\text{-}Cuy)\text{-}O_{8+\delta}$ [chu et al, Phil. Mag. Lett. 75, 15 (1997)]	1. **Oxides** $SrTiO_{3-x}$, $AxWO_3$(A=Rb,Cs) $BaPb_{1-x}BixO_3$ $Li_{1-x}Ti_{2-x}O_4$, $Ba_{0.6}K_{0.4}BiO_3$ $La_{2-x}MxCuO_4$(M=Ca,Ba) 2. **Chalcogenides** $SnNbS_3PbTaS_3$ A_xMX_2(M=Nb,Ta,Mo & X-S, Se, A=metal) $CuRh_2X_4$ (X-S,Se, Spinels) A_xMo_6X (A=metal, X-S,Se $Mo_6S_6I_2$ 3. **Misc. Ternaries** Borides, $LnRh_4B_4$(Ln=Rare) earth or Y), $LuRuB_2$. $LaRh_3B_2$ **Carbides:** Mo_3Al_2C, Mo_2BC **Silicides:** $CeCu_2Si_2$, $Ln_2Fe_3Si_5$, $Ln_5M_4Si_{10}$ (M=Co,Rh, Ir) **Germanides:** $Ln_5M_4Ge_{10}$, $Ln_3M_4Ge_{13}$, LnM_2Ge_2 (M=Pd,Pt,Ru,Os) Stannides: AMxSny (A=metal or Ln, M=Rh, Os, x=1 & y=3-4) **Pnictides** ZrRuX(X=P, As), NbPS, LnM_4X_{12} (M=FeRe)

Milestones in superconductivity

1911 : Dutch physicist H.K. Onnes discovered Superconductivity at temperature of 4.2K.
1913 : H.K. Onnes was awarded the Nobel Prize for aforesaid discovery.
1933 : W. Meissner and R. Ochsenfeld discovered flux exclusion (Meissner effect).
1935 : London phenomenological theory was preposed.
1941 : Super conductivity in niobium nitride at temperature of 16K was reported.
1950 : Discovery of the isotopic effect; the importance of electron – phonon interaction was emphasised by Frohlich.
1953 : Experimental evidence for energy gap in superconducting state was reported.
1957 : The microscopic theory of super conductivity, popularly known as B. C. S. theory, was given by J. Bardeen, L. Cooper and R. Schrieffer.

1960 : Tunnel effect was discovered by Giaever.
1962 : Giaever and Josephson discovered Josephson effect. Also first commercial niobium titanium superconducting wire was fabricated.
1964 : Flux quantisation was discovered by Deaver et al.
1972 : Bardeen, Cooper and Schrieffer were awarded the Nobel Prize for B.C.S. Theory.
1986 : K.A. Miller and J.G. Bednorz discovered superconductivity in La-Ba-Cu-O ceramic oxide at 32K.
1987 : Superconducting transition temperature (T_c) = 92K was reported by M.K. Wu et al in Y-Ba-Cu-O ceramic oxide.
1988 : H. Maeda et al reported T_c = 110K for Bi-Sr-Ca-Cu-O ceramic oxide.
1988 : A. Hermann and Z.Z. Sheng reported superconductivity in Tl-Ba-Ca-Cu-O compound at 125K.
1993 : T_c = 155K in Hg-Ba-Cu-O material was reported by A. Schlling et al.
1994 : With no reproducibility T_c = 250K was reported by J.L. Tholence et al in Hg Ba_2 Ca_{n-1} Cu_n $O_{2n+2+\delta}$.
2003 : A. Abrikosov, A. Leggrett and V.L. Ginzburg awarded Nobel Prize for their theoretical research work about how matter can depict very strange behaviour at low temperatures (superconductivity and superfluidity).

The Signature of the Superconducting State

The superconducting state may be identified by abrupt changes in physical properties of the material. Some of the important ones are the disappearance of electrical resistance, perfect diamagnetism, abrupt increase (jump) in the specific heat at T_c characteristic change in the microwave absorption, persistent current, the Meissner effect and flux quantisation. Fig. 2 shows a typical plot for the disappearance of electrical resistance [15] for BiSrCaCuO (SBi) (110K) sample. This plot can be divided into two states viz normal state which is metallic from room temperature down to transition temperature (T_c) and superconducting state manifested below T_c. Specific heat of the superconductor changes at T_c in the characteristic way (Fig. 3). There is a discontinuity at T_c. At temperature immediately below T_c, the specific heat is much larger than in the normal state so the sudden jump together with the more rapid decrease with decreasing temperature, given rise to this characteristic shape below the transition.

Below the transition temperature all high T_c ceramic oxide superconductors exhibit a large microwave absorption at very low magnetic field. The typical derivative of low field microwave absorption spectra for Y BaCuO (SY) & BiSrCaCuO (SBi) samples are shown in Fig.4. The microwave absorption has been attributed to the granular nature of these ceramic oxide samples.

It has been observed that if in a closed loop of superconducting wire initially current is passed, then this current will keep flowing around the loop on its own as long as the wire is kept cooled ($T<T_c$). Such a steady current that flows without any resistive loss is called

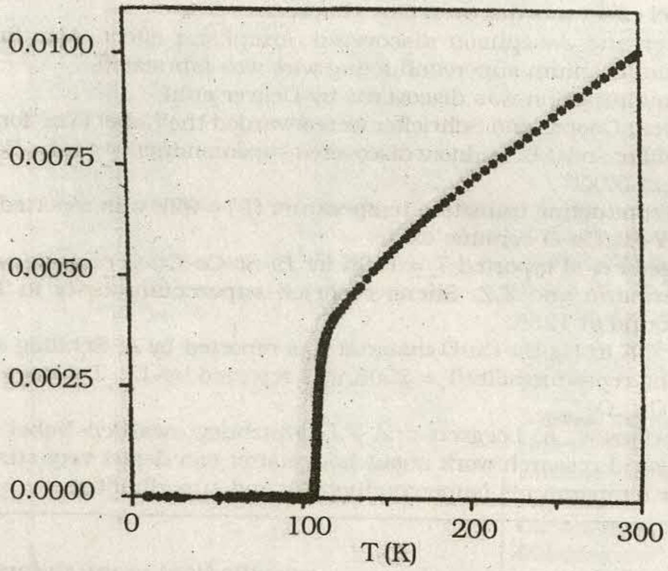

Fig.2: Resistivity (ρ) Vs T

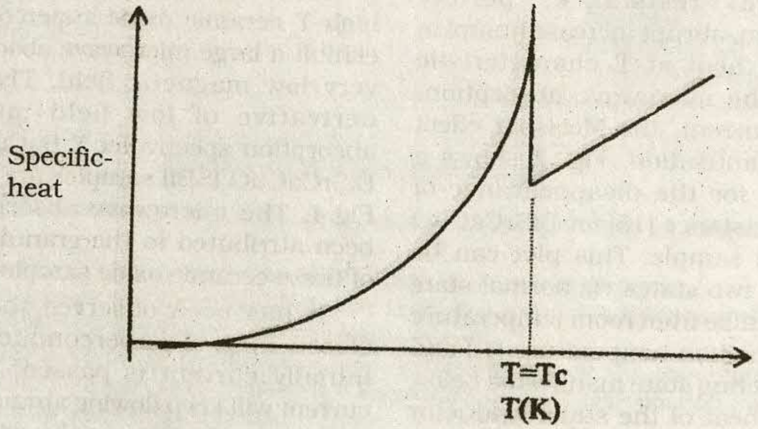

Fig.3: Specific heat Vs T

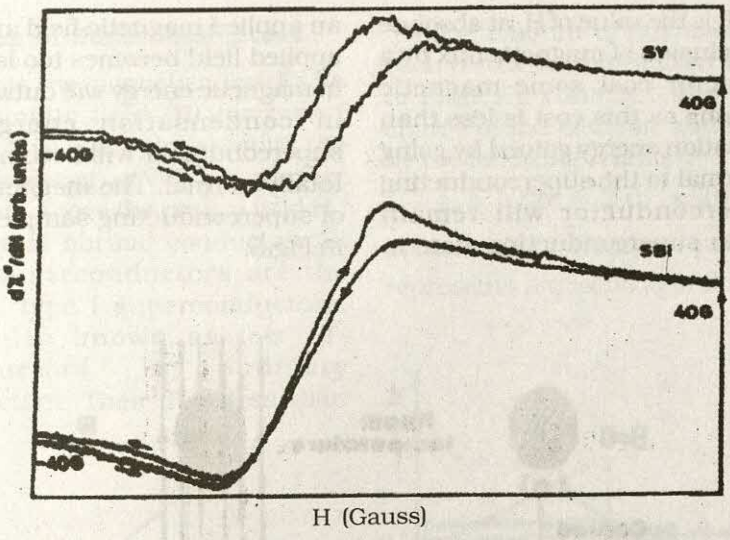

Fig.4: Microwave absorption Vs H

a persistent current. In one case, a current that was started in a superconducting loop kept on flowing for two and half years with undiminished strength and it would probably still be flowing today if the experiments had not run out of liquid helium for cooling the apparatus. The decay formula is $I - \exp[(-R/L)t]$ so once started, current in superconducting loop will continue to flow indefinitely as long as the temperature and magnetic field remain unchanged, because the decay time of the current governed by the inductance to resistance ratio which is infinite as the resistance is zero.

In 1933, Meissner and Ochsenfeld showed that if a long cylindrical superconductor is cooled in a longitudinal magnetic field below its T_c, the lines of induction will be pushed out of the material due to infinite conductivity. The expulsion of magnetic flux from a superconducting material during the transition from normal to the superconducting state is called the Meissner effect. Meissner effect shows that superconductor behaves as inside it the specimen B=0. Hence from the following relation:

$$B = H + 4\Pi M \text{ or } H = -4\Pi M.$$

The magnetic susceptibility (...) = $M/H = -1/4$ II. i.e. a super conductor exhibits perfect diamagnetism. *This also suggests that perfect diamagnetism and zero resistivity are two independent properties of superconducting state.* There is always some critical magnetic field H_C, above which superconductivity disappears. This field has got temperature dependence which is expressed by the following empirical relation:

$$H_c(T) = H_c[(1 - (T/T_c)^2].$$

Where H_o is the value of H_c at absolute zero. The exclusion of magnetic flux by a superconductor cost some magnetic energy. So long as this cost is less than the condensation energy gained by going from the normal to the superconducting state, superconductor will remain completely in superconducting state in an applied magnetic field at $T < T_c$. If the applied field becomes too large, the cost in magnetic energy will outweigh the gain in condensation energy and the superconductor will become partially or totally normal. The magnetic behaviour of superconducting sample is displayed in Fig.5.

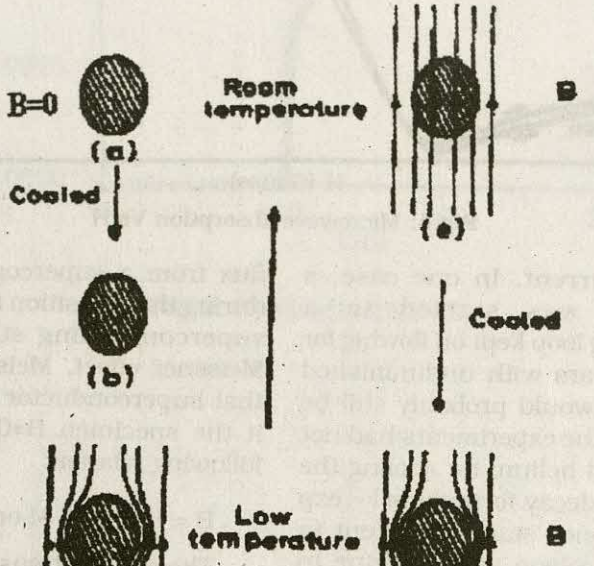

Fig.5: Magnetic behaviour of superconducting sample – [(a)–(b) sample becomes resistanceless in the absence of magnetic field, (c) magnetic field applied to a superconducting sample, (d) magnetic field removed, (e)–(f) sample becomes superconducting in applied magnetic field and (g) applied magnetic field removed].

Classification of Superconductors

Fig.6(a) depicts the magnetisation (M) Vs applied magnetic field (H) for type I superconductors. This plot exhibits the complete Meissner effect i.e. perfect diamagnetism. Above the critical field H_c, the specimen is normal conductor. All elemental superconductors are the examples of type I superconductors. They are also known as low T_c superconductors or ordinary superconductors. Their T_c is less than 30K.

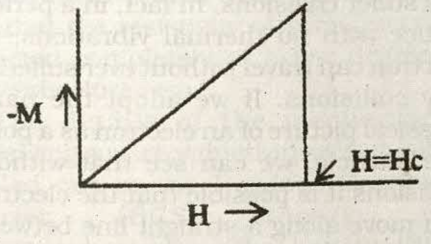

Fig.6(a): M Vs H for type I superconductors

Fig. 6(b) shows the magnetism vs applied magnetic field for type II superconductors. The flux starts to penetrate the sample at field H_{c1} which is lower than the critical field H_c. The sample is in a mixed or vortex state between H_{c1} and H_{c2} and it has superconducting properties upto H_{c2}, which is called upper critical magnetic field. Above H_{c2} sample is normal conductor. All high T_c ceramic oxide superconductors are the examples of type II superconductors. They are also known as cuprate or ceramic oxide high T_c superconductors. Their T_c is greater than 30K.

The amount of flux associated with each vortex line has a fixed value related to Planck's constant and the electric charge of the electron and is expressed by the following relation:

$\phi_0 = h/2e = 2.07 \times 10^{-15} \mathrm{Tm}^2$. This means that flux is quantised. ϕ_0 represents a quantum of flux.

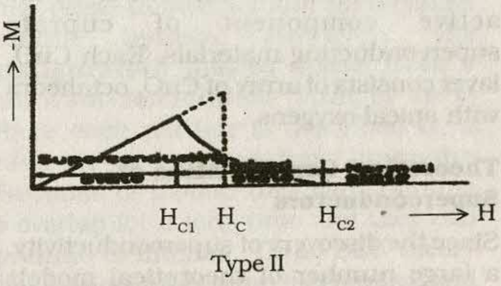

Fig. 6(b): M V_s H for type II superconductor

Structure of superconducting materials

All high T_c superconductors are characterised by large unit cell volume and pronounced layers anisotropy. Superconducting properties of these oxide superconductors are seem to be caused by the availability of plane layers of Cu and O ions in their unit cells. Most of ceramic oxide high Tc superconductors are having perovskite (ABC_3) type structure. In Y-Ba-Cu-O superconductors in such planes the chains of alternating copper and oxygen ions are clearly distinguished. In majority of other oxides the plane layers of Cu and O ions are formed by two mutually

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perpendicular chains of alternating copper and oxygen ions. All cuprate high T_c superconducting materials are quasi-two-dimensional materials containing one or more CuO_2 layers in each of unit cell. The copper-oxygen layers are separated either by intervening CuO chains or by layers containing other metals or metal oxides (BaO, BiO, TiO, etc.) that serve as the carrier reservoirs. The CuO_2 layers are believed to be the active component of cuprate superconducting materials. Each CuO_2 layer consists of array of CuO_6 octahedra with apical oxygens.

Theoretical Consideration of Superconductors

Since the discovery of superconductivity, a large number of theoretical models have been proposed to explain the phenomenon. London theory, Pippard model, Gunzburg-Landau theory Abrikosov's model and BCS theory have been proposed in case of low temperature superconductors (T_c<30K). Out of these theories only the BCS theory was found quite satisfactory for classical superconductors but failed completely to explain the observed properties e.g., isotope effect, electronic specific heat at low temperature and independence of T_c on the number of charge carriers in high T_c oxide superconductors. Charge transfer excitation exchange, Excitation mechanism, Virtual magnetic excitations, Resonating Valence Bond (RVB) theory, Bipolaron mechanism, Mean field theory, Spinons and Holes, Scaling theory, Gauge theory, String and spin beg theories have been proposed to explain the superconductivity in high Tc oxide superconductors. None of the proposed theories have been considered to be a confirmed theory of superconductivity. Howerver, the strong electron phonon coupling or spin fluctuation may still be playing important role within the B.C.S. pairing framework. Let us discuss how zero resistivity is explained on the basis of B.C.S. theory. "The resistivity depends on temperature because the random thermal motion of the ions of the lattice increases the likelihood that an electron will suffer collisions. In fact, in a perfect lattice with no thermal vibrations, an electron can travel without ever suffering any collisions. If we adopt the naive classical picture of an electron as a point like particle, we can see that without collisions it is possible that the electron can move along a straight line between the rows of atoms. This classical picture of the motion of electron has been shown to be invalid by modern quantum mechanics, according to which electrons have wave properties, however, it turns out that the quantum mechanical picture of the motion of electron waves leads to a similar conclusion. The electron wave can travel through a perfect crystal lattice without suffering any scattering, because whatever effect is caused by one atom is canceled by the effect of other atoms. The quantum mechanical picture indicates that in a perfect crystal lattice the electron wave can travel unhindered in any direction. Imperfections in the regularity of the position of the atoms of the lattice will hinder the propagation of the electron wave and give the metal a finite resistivity. Thus, random thermal vibrations of the ions contribute to the resistivity. At low temperatures, the reduction of these thermal vibration brings about a reduction of resistivity at zero temperature, when the thermal vibrations disappear, the resistivity should also disappear (except for a residual contribution due to impurities and dislocations of the lattice). It, therefore, came as no surprise to physicists that experimental values of the resistivity were small at low temperatures — what came as a surprise was that the resistivity of some metals vanished completely at a few degrees above absolute zero."

The details of the mechanism underlying superconductivity were finally spelled out in the Bardeen-Cooper-Schrier (BCS) theory of superconductivity. The key to this mechanism is the formation of electron pairs (Cooper pairs). After many false starts, theoretical physicists recognised that the free electrons in a metal are not quite free, but they interact with another via the lattice. The negative charge of each free electron exerts an attractive force on the positive charges of the ions of the lattice, consequently, the nearby ions contract slightly toward the electron. This slight contration of positive charge, in turn, attracts other electrons. The net effect is that a free electron exerts a small attractive force on another free electron. Although this attractive force is too small to be of any consequence at room temperature, it is strong enough to permanently bind two electrons into a pair when the temperature is within a few degree of absolute zero, where the thermal disturbances nearly disappear. In a superconducting metal in electrostatic equilibrium (no current), each cooper pair consists of two electrons of exactly opposite moments. Obviously such a configuration makes no sense from a classical point of view. If two particles have opposite and constant momenta, they will travel away from each other in opposite directions; they will then cease to interact and they cannot remain bound. However, the configuration makes sense from a quantum-mechanical point of view, where each particle is described by a wave—if two waves have opposite directions of motion they can continue to overlap for a long time and they can continue to interact. Thus, BCS theory is intrinsically quantum mechanical and the language of classical physics can only convey a crude outline of the theory. "In a superconducting metal carrying a current, the electron pairs have a net momentum in the direction opposite to that of the current and they transport electric charge. The electron pair moves through the lattice without resistance, because whenever the lattice scatters one of the electrons and changes its momentum, it will also scatter the other electron of the pair and change its momentum by an opposite amount. Consequently, the lattice cannot change the net momentum of a pair. It can neither slow down nor speed up the average motion of the pair electrons". The existence of energy gap ($2\,\Delta$) has been confirmed by many experiments and is given by the following relation:

$$2\,\Delta = 3.52\,KT_C$$

Superconducting Fluctuations

It has been reported that thermodynamic superconducting fluctuations result in cooper pair formation with some finite probability for $T > T_c$. For $T > T_c$, the variation of resistivity with temperature could be thought of as essentially metallic in nature and expressed as:

$$\rho(T) = a + bT$$

Anderson and Zao, however, developed a relation based upon RVB theory, which takes care of the metallic conductivity in the CuO planes and semiconducting behaviour for conduction, process between the planes and across the grain boundaries expressed as:

$$\rho(T) = AT + B/T$$

where linear term takes care of the ab – plane resistivity and the B/T term accounts for c-axis variation. Aslamzov and Larkin (AL) predicted that for the BCS superconductivity there is an excess conductivity ($\Delta\sigma$) above T_c due to electron pairing expressed in the mean field region by the following relation:

$$\frac{\Delta\sigma}{\sigma rT} = A\varepsilon^{\lambda}$$

Where $\sigma rT = 1/\rho rT$, ρrT is resistivity at room temperature.

$$\Delta\sigma = \sigma \text{ measured} - \sigma \text{ background}$$

$$= \frac{1}{\rho_m} - \frac{1}{\rho_b}$$

ρ_m = measured resistivity, ρ_b = is the resistivity (normal state) at high temperature extrapolated to lower temperature.

$$\varepsilon = \frac{T - T_c}{T_c} = \text{reduced temperature,}$$

λ = Critical exponent and A = a temperature independent constant having following forms:

$$A = \frac{e^2}{32h\,\xi_{(0)}\sigma rT} \quad \text{for } \lambda = -0.5,\ 3D$$

$$A = \frac{e^2}{16h\,d\,\sigma rT} \quad \text{for } \lambda = -1.0,\ 2D$$

$x_{(0)}$ is Zero temperature coherence length. It is the distance over which the energy gap can not change appreciably in a specially varying magnetic field. D = a characteristic length of 2 D system. Both λ and A depends on dimensionality (D) of the fluctuations as

$$D = 2(2 - \lambda)$$

Methodology of Sample Preparation

Discovery of high T_c superconductor (superconductor $T_c > 30K$), the most common route to synthesise these materials is the standard ceramic technique. This involves a solid state reaction in which both reagents and products are in solid state, usually the starting constituents are in their oxides, carbonates and nitrates forms. This method consisted of generally three steps, (i) Homogeneous mixing (can be achieved simply by ball milling or grinding all constituents in acetone or methanol media followed by pelletisation), (ii) calcinations (to remove the carbonates present in the mixtures it can be done by heating the pelletised mixture at above 800°C for 24 hours) and (iii) sintering/annealing can be performed by heating the re-pelletised material (Step ii) at relatively higher temperature for longer time in air/O_2 atmosphere.

Another technique, known as glass ceramic technique has been used to synthesise the superconducting material. This is most common technique for the synthesis of glass ceramic materials which involves the following steps—(i) preparation of precursor of desired stoichiometry of samples (this can be completed by adapting the same procedure as that of ceramic technique till step (ii), conversion of precursor into amorphous matrix (this is done by melting the mixture of step (i) followed by splat quenching between two thick copper plates) and (iii) crystallisation and nucleation growth of super-conducting phase (this is performed simply by heating the unquenched material at respective temperature and time in air atmosphere).

Characterisation Techniques

Superconducting samples have been characterised using mainly dc - electrical resistivity by four probe method, ac-magnetic susceptibility (χ), electron para magnetic resonance, microwave absorption, x-ray diffraction, scanning electron microscope and energy dispersive x-ray analysis.

Potential Applications of Superconductivity Magnetically Levitated Trains

Persistent current induced by changing magnetic field bring about some spectacular levitation effects. If a bar magnet is dropped towards a super conducting dish, the magnetic field induces persistent currents along the surface of the dish; by Lenz law, the direction of these currents is such that their magnetic force on the magnet is repulsive. As an example of an application of superconductivity, let us consider magnetic suspension of trains. A permanent magnet will remain suspended over a superconducting sheet the former induces currents in the latter and the magnetic force on the currents is repulsive. If we replace the permanent magnet by a superconducting coil with a current (a superconducting magnet), we will get the same repulsion effect. Taking advantage of this, we could attach superconducting magnets to the underside of a train and levitate it on superconducting rails. The suspension is frictionless—the train on a cushion of magnetic fields and slides without friction. In practice, this ideal arrangement is not feasible because it would be too much expensive to lay down hundreds of kilometers of superconducting rails. However, it is also possible to obtain levitation with rails made of an ordinary conductor. In this case, there is no repulsive force between the superconducting magnets and the rails when they are at rest, but there is a force when they are in motion relative to one another, because the moving magnetic field induces currents in the rails. These currents suffer some resistive loss, but the effective frication would be reasonably small. It has been reported very recently that engineers have fabricated magnetically levitated train with speed of 350 km/hr.

Superconducting Magnet

Conventional electromagnets with copper windings and iron cores are among the least energy-efficient devices produced by our technology. They consume enormous amounts of electric power merely to keep a constant current around the coil. Except for the magnetic energy initially stored in the electromagnet at startup, all of the electric power is wasted as heat. By contrast, a magnet with superconducting coils requires no electric power at all to keep running. Of course, the superconducting magnet must be cooled to a low temperature and maintained at this temperature. The initial cooling and the continual removal of any heat that leaks into the magnet from the environment require refrigeration and a supply of coolant, such as liquid helium. A superconducting magnet capable of generating a magnetic field of 15T; magnetic field of this strength is very difficult to attain with a conventional magnet. Superconducting magnets have been installed at the Fermilab accelerator. This machine was originally build with conventional magnets, but in order to make the machine capable of handling particles of higher energy, new superconducting magnets producing more intense magnetic fields were required. Fermilab developed 7m long superconducting magnets producing fields were required. Fermilab developed 7m long superconducting magnets producing fields were required. Fermilab developed 7m long superconducting magnets producing a magnetic field of up to 4.5T. The complete accelerator ring 6.2 km in circumference has 774 of these magnets plus 240 extra magnets used for focusing the beam of high energy particles. The ring of superconducting magnet is placed just below the ring of ordinary magnets. Particles are first accelerated in the ordinary ring and then fed into the super-ring, where they reach a final energy of 106 MeV.

Transmission and Storage of Electric Power

The transmission and storage of electric power are another important application of superconductors. Resistive losses in conventional transmission lines are of the order of 10% to 15% of the total power transmitted. A superconducting cable would of course eliminate the loss. However, from a financial point of view, the elimination of the resistive loss makes only a minor contribution to the thriftiness of superconducting cables; what makes a major contribution is their compact size – large amount of power can be carried by a single cable of fairly small dimensions that can be installed in an underground tunnel not requiring the expensive strips of real state on which conventional transmission lines are erected. An experimental version of a superconducting transmission line (the outside diameter of the pipe enclosing the cable is 40 cm) can carry a power of 1000 MW, roughly the total power of a nuclear generating station.

Another possible application of superconductivity is the storage of electrical energy. Because of daily fluctuations in the demand for electric power by a city, it is desirable to hold large amount of electrical energy temporarily in some kind of storage system. The power can be fed into the storage system when the demand is low and released when the demand is high. Table 2 compares the energy density in several systems. It is obvious from the given table that magnetic fields constitute one of the most concentrated forms of stored energy.

Table 2 : Comparison of Energy Storage of Different Systems

System	*Energy density*
Magnetic fields, 10T	11kW h/m3
Electric field, 10^5 kV/m	0.01
Water in reservoir, height 100m	0.27
Compressed air, 50 atm	5
Hot water, 100°C	18

Electrical Switching Element

Because of the infinite ratio between the resistance of a metal in the normal and superconducting state a superconductor can be used to switch electrical current between different possible paths. Either temperature or magnetic field can be used to control the change of state of such a switch. A temperature controlled switch uses a film of lead as the switching element. The current carrying film is operated below the T_c so as to be superconducting. The current can be interrupted by means of a heating coil made of non-superconducting material. As the lead film becomes resistive, the current flowing through it is diverted through a parallel path of low resistance.

Superconductor Fuse

Thin insulated superconductor film gets its normal states after the current of more than critical current density has passed through it. Such films can be used instead of a fuse. Selecting the required material for a film it is possible to regulate very precisely the admissible intensity of current. If a long film is taken and at the moment of its transition into normal state its resistance is rather high, then it can be used as a breaker. Lead is used for this purpose.

Electric Motor and Generator

One more field of application of superconductors is the manufacture of electrical machines, transformers, generators and motors • with superconducting windings. It is possible to obtain high efficiency and small sizes weight by using superconducting wires. The possibility of achieving extremely strong magnetic fields and using loss less coils to cut those fields is of great interest to the power engineer. The most encouraging work that has been done in producing rotating machinery, on the industrial side rather than on the laboratory scale, has been concerned with d.c. machines. In particular, a superconductor homopolar motor has been widely used for plant operation. In this simple form, the homopolar machine uses or generate electrical power in the form of a very high current at very low voltage. Applications of particular superconductors promise for the d.c. superconducting motor appear to lie in fields like ship propulsion and large mills, where very high torques are required at comparatively low speeds. In terms of capital and running costs, they are likely to be competitive with conventional machines for large output powers and smaller, lighter and more efficient.

Medical Application of Superconductivity

One significant application of superconductivity which has gone from laboratory to hospital as diagnostic tool called Magnetic Resonance Imaging (MRI). In fact MRI is not really a form of magnetometry, although MRI does depend on superconductivity. Instead, MRI relies on magnetism and a special kind of behaviour of atom in a magnetic field. The nuclei of many atoms, notabley hydrogen atoms, act like tiny magnets. When an outside magnetic field appears, these magnet like nuclei tend to line up with field like a compass needle. Some atomic nuclei try to point out the other way, but orienting against the magnetic field is not energetically favourable. The signal used for MRI imaging comes about from the dynamic action of these nuclear magnets. When an atomic nucleus switches from being aligned against the magnetic field to being aligned with the magnetic field, a small amount of energy is released. The energy takes the form of an electromagnetic (wave). The Frequency emitted depends on the strength of the magnetic field and the particular kind of atom that emits the energy. The MRI imaging process begins by placing the patient in the bore of a cylindrical magnet. The magnet maintains a steady, precise magnetic field through a cross-section of the patient's body. The magnetic field aligns the nuclei of the body's atoms and sets the frequency of the electromagnetic energy they emit. Then we supply a sharp electromagnetic pulse which temporarily scrambles many of the atomic alignments with the magnetic field. After the pulse has ended, the nuclei can realign with the magnetic field and when they do they emit their characteristic radio signal. Arrays of detectors pick up the emitted (electromagnetic) radio waves for computer analysis. Sophisticated computer analysis then translates the data into a complete picture of a magnetic slice through the body. An MRI corresponds to taking an electronic census of the body's hydrogen atoms. Hydrogen turns out to be a very useful monitor of the body' health. Since two-thirds of water consists of hydro-gent atoms, water rich tissues respond strongly to MRI probes. Most organic materials are also hydrogen rich and also show up readily in MRI scans. In contrast, bones remains relatively dark. That is a big plus point of doctors trying to examine brain tissue otherwise hidden by the skull.

Superconducting Super Collider (SSC)

During the 1980s, the scientific community made a bold proposal for the construction of a superconducting super collider about 84 kms. long that would use superconducting magnets to create particle streams with enough energy to explore the structure of elementary particles. Recently, Superconducting Quantum Interference Device (SQID) used to study tiny magnetic signals in the brain has been fabricated by using high T_c superconductors.

Conclusion

It has been concluded that the rounding of resistivity plots in the transition temperature regime in polycrystalline high T_c superconductors. Dimensionality of superconducting fluctuations estimated from the SFC has been found to be 3D in case of La-Sr-Cu-O and Y-Ba-Cu-O samples with critical exponents $(\lambda) = -0.5$ and 2D for sample Bi-Pb-Sr-Ca-Cu-O with $\lambda = 0.96$ in mean field regime. Superconducting magnet (15T), cryotron, superconducting cable, energy storage device, super-conducting power transmission line, magnetically levitated train, superconducting super collider, superconducting fuse and magnetic resonance imaging have been constructed and their applications have gone from laboratory curiosity to sidespread practical applications. It is expected that there would be further advancement in the potential technological applications of superconductors leading to significant advantages in efficiency and energy saving, So, what initially seemed to be a merely theoretical concept, will have a lot of potential for welfare of our society.

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Nanotechnology : Applications Galore

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THE ARTICLE in the previous issue of the Journal focussed on the world of nanotechnology. The new laws of physics that govern the matter at nanoscale and also different approaches for the fabrication of nanostructures were discussed. There is full agreement among the experts worldwide that nanotechnology will be one of the key technologies of the 21st century. Energy, environmental technology, information technology, material science and medicine are just a few of the areas that will be deeply influenced by nanotechnology. Let us have a brief overview of the applications of nanotechnology in some key areas.

Material Science

Scientists have begun to mix and match the attractive properties of certain chemicals to produce strongest and lightest material using nanotechnology. It has been possible to make products like pants woven from nanofibres that resist stains. Clothes resistant to wrinkles have also been fabricated. Fabrics have also been produced that are stronger or more resistant to heat. Tennis balls that keep their bounce even after prolonged use have also been fabricated using nanotechnology. Nanoceramics, nanopolymers and nanocomposites may have plethora of applications. The size and weight of vehicles and spacecrafts may be much reduced by fabricating them using nanocomposites. This will make vehicles and spacecrafts not only convenient to handle but energy efficient too. Types of vehicles may be made using nanopolymers. This will not only enhance the life of the tyres but will also keep a check on the minute harmful particles that fly off from these tyres and reach the environment.

Electronics, Computers and Robotics

Researchers have been able to create nanometre-scale electronic components-transistors, diodes and logic gates from carbon nanotubes. It will be possible to have faster and smaller transistors, thanks to nanoelectronics. Nanowires for joining the electronic components have also been fabricated using nanotubes. The scientists at the IBM Corporation are now busy studying light-producing nanotubes that could perhaps be used in the distant future for a quick exchange of more information between a microprocessor and a memory chip. This will pave the way for the development of faster and smaller computers in future.

Sandwiching several nonmagnetic layers, one of which is less than a nanometre thick, between magnetic layers can produce sensors for disk drives with many times the sensitivity of previous devices, allowing more bits to be packed on the surface of each disk.

This will manifold increase the information storage capacity of the disk.

Scientists are also investigating the possibility of making structures from colloids viz., nanoparticles in suspension. Christopher B. Murray and a team at the IBM J. Watson Research Centre are exploring the use of such colloids to create a medium for ultrahigh-density data storage. The IBM team's colloids contain magnetic nanoparticles as small as three nanometres across, each composed of about 1000 iron and platinum atoms. When the colloid is spread on a surface and the solvent allowed to evaporate, the nanoparticles crystalise in two-or-three dimensional arrays. Initial studies indicate that these arrays can potentially store trillions of bits of data per square centimetre, giving them the capacity 10 to 100 times greater than that of the present memory devices.

Thus, nanotechnology is poised to revolutionize the information technology by allowing for faster information processing. Moreover, as computer parts shrink and become more powerful, the scientists expect to be able to build mini robots that could be programmed to accomplish any task, including replicating themselves. The mini robots will have potential applications in various fields including medicine.

Energy and Environment

The nanostructured materials will help reduce the size and weight of vehicles and spacecrafts thus reducing their energy requirements. Not only this but nanopowders may be used for the production of batteries or fuel cells. When used in electric or hybrid cars they are expected to tremendously improve their performance and energy efficiency. Nanoscopic filters having holes between 10 and 100 nanometres can be used to remove very fine particles from petrol and diesel making these fuels more energy efficient. In nuclear power plants too nano filters may be used for fuel processing and management of nuclear waste.

Filters made of nanomaterials may be used for removing undesirable substances and pollutants from air as well as water. Thus, nanotechnology is expected to touch every facet of our lives, from the water we drink to the air we breathe. Nanotechnology can also be used for evolving green manufacturing processes that minimise the generation of unwanted by-products.

Medicine

Medical explorers are exploiting the tools of nanotechnology to manipulate the key biomolecules that regulate life and death, health and sickness. Nanotechnology has allowed researchers to develop specialised polymers, called dendrimes, which function as targeted vehicles for gene therapy so that they can replace the defective gene in the cell with a normal gene, and cure the patients.

Medical researchers have used nanotechnology to fabricate silicon capsules with nanoholes of about 18 nanometres size. These holes are small enough to keep the antibodies out, thus preventing immune rejection. However, glucose and insulin molecules are small enough to travel freely through the nanoholes, allowing them to regulate the blood sugar levels.

Nanotechnology will make possible creation of nanometre size robots, called nanobots, which could revolutionize medical diagnosis. These nanobots can cruise through the bloodstreams, banishing disease and debility by searching out and destroying viruses and bacteria. More advanced nanobots capable of self-replicating and following directions may act as 'smart bombs' destroying the cancerous cells and tumors. They can also be used for repairing damaged tissues.

The acceptance of implants in the body can be increased by putting a self-organising mono-molecular layer on the implant. This will allow cell growth and help the body to accept the implant much faster.

Nanoparticles could be used to deliver drugs in correct proportions just where they are needed, avoiding the harmful side effects.

Indeed, nanotechnology has a much broader scope. Molecularly engineered biodegradable fertilisers and pesticides may become possible in the future. This will help protect humans and the entire biosystem from the ill-effects of fertilisers and pesticides.

It will also be possible to develop much advanced agricultural equipments using nanotechnology. It will also be possible to develop sensors which will monitor the growth, metabolism and requirements of plants, resulting in increased agricultural yield.

The minerals called zeolites have pore sizes of less than one nanometre. They can serve as more efficient catalysts to breakdown, or crack, large hydrocarbon molecules to form gasoline.

The field of microelectromechanical systems (MEMS) has led to development of micromachines. They have important applications in many fields including medicine. But, now the scientists have startedthinking about nanoelectromechanical systems (NEMS) which will make the development of nanomachines possible. Resonant detectors are generally used for sensing mass. The vibrations of a tiny mechanical element, such as a small centiliver, are intimately linked to the element's mass, so the addition of a minute amount of foreign material (the 'sample' being weighed) shifts the resonant frequency. But, now nanoelectromechanical resonant detectors can be made. They will be so sensitive that 'weighing' individual atoms and molecules becomes feasible. But, the most potential applications of these nanoscale devices will be in the development of ultraminiature 'smart' sensors that could continuously monitor all the important functions in hospitals, in manufacturing plants, on aircrafts, and so on. Indeed, the idea of ultra-miniature devices that drain their batteries extremely slowly has great appeal.

Indeed, nanotechnology is going to be the future face of technology. It is expected to transform almost every facet of human existence and has the potential to lay the groundwork for a new industrial revolution. There is no gainsaying that the richness of the nanoworld will change the macroworld.

However, we will have to fully understand the science underlying nanotechnology. Then only it will be possible to identify worthwhile nanotechnologies to pursue. In this manner we will ultimately be able to build the road to true nanotechnology. This will also be in tune with the futuristic vision of Richard Feynman that nature has left plenty of room in the nanoworld to create practical devices that can help humankind.

Use of Isotopic Labelling in Tracing Mechanism of Organic Reactions

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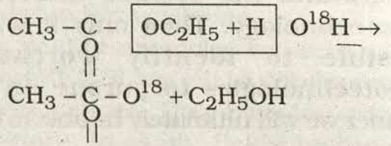
MECHANISM is the actual process by which a reaction takes place. One of the important point which it tells about the reaction is that, it explains which bonds are broken in the reaction and what is the order of breaking of bonds. It also explains the position of attack of a reagent and tells about the intermediates formed during the reaction. In the present article use of isotopic labelling in tracing the mechanism of a reaction has been explained. Isotopic labelling may be used to trace the path of the reaction and it may be used to identify the bond broken. It is not necessary to use completely labelled compounds. Partially labelled material is usually sufficient for this purpose.

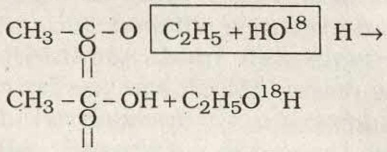
These things has been explained with the help of examples given below:

Identification of Bonds Broken in the Hydrolysis of Ester

Ester hydrolysis: Hydrolysis of an ester with an acid or a base as a catalyst can take place in two different ways giving an alcohol and an acid. These are given below:

(i) 

$$CH_3-\overset{}{\underset{\overset{\|}{O}}{C}}-\boxed{OC_2H_5+H}\ O^{18}H \rightarrow CH_3-\underset{\overset{\|}{O}}{C}-O^{18}+C_2H_5OH$$

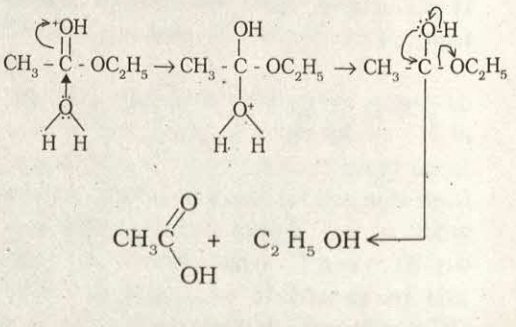
(ii) 

$$CH_3-\underset{\overset{\|}{O}}{C}-O\ \boxed{C_2H_5+HO^{18}}\ H \rightarrow CH_3-\underset{\overset{\|}{O}}{C}-OH+C_2H_5O^{18}H$$

If water having O^{18} isotope of oxygen is used for hydrolyosis and if route (i) is followed then alcohol so formed after hydrolysis will not contain any O^{18} isotope but if route (ii) is followed then alcohol formed will have O^{18} isotope.

Actually it was found that alcohol so formed does not contain O^{18} isotope. Therefore, the correctness of the reaction is that C-O bond of the ester is broken as in (i).

There is no doubt, therefore, that hydrolysis is following route (i) as given earlier. Now the mechanism of the reaction can be written as follows:



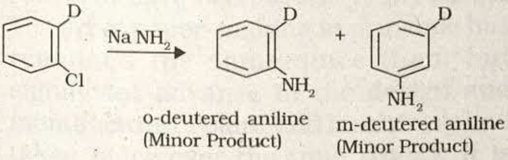
(Acid Catalysed hydrolysis mechanism)

Identification of Position of Attack of Reagent

Fusion of Chlorobenzene with $NaNH_2$ (Sodamide) gives aniline. Is it a pure nucleophilic substitution reaction? Yes it is a nucleophilic substitution reaction. But neoleophile NH_2 does not attack at the same position from where C1 leaves.

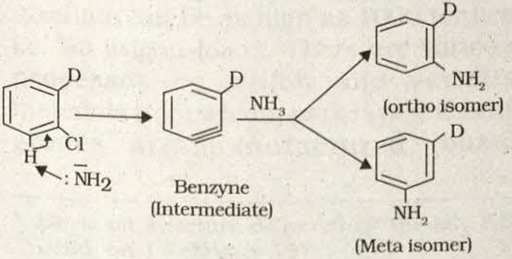
What actually is taking place must be known in order to write the mechanism of the substitution reaction.

Fusion of O-Deutero-Chlorobenzene with sodamide gave a mixture of two production O - Deutero aniline and m - deutero aniline. If it is simple substitution reaction it would have given only O - Deutero aniline and no m - produce would have formed.



How to explain this.

The best possible way of explaining this is through the formation of benzyne intermediate as explained below:

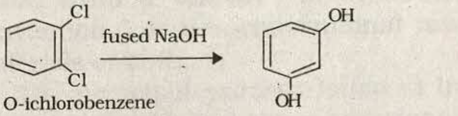


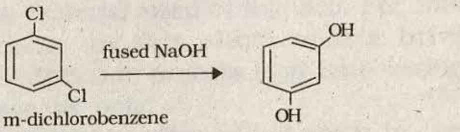
It should be noted that in benzyne intermediate there is one triple bond. The attack of reagent may take place at ortho as well as meta position with respect to deuterium. Hence two products are formed:

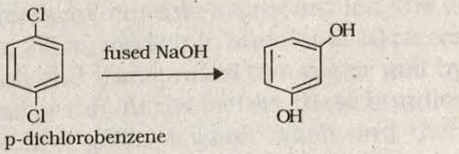
If this mechanism is correct then fusion of O-, m-, p-, dichlorobenzene with sodium hydroxide m-dihydroxy benzene will be obtained.

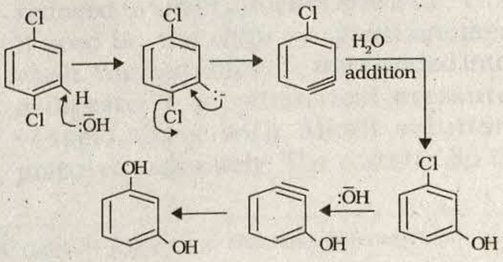
Actual experiments show that in all the three cases m-dihydroxy benzene (resorcinol) is obtained.

Take the example of p-dichlorobenzene and how it gives resorcinol.









Since –Cl makes the o- and p-position more electron rich, therefore: OH of water attacks the m- position replacement of second chlorine occurs when one: OH group is already present in the ring. Again reaction proceeds through benzyn intermediate. In this example one can see that with the help of isotopic substitution position of attack of reagent can be located, which is not the same from which leaving group leaves.

Pulp and Paper*

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Pulp and Paper Industry is one of the most important industries for a civilised society. Had there been no paper industry and availability of paper, the spread of knowledge and communication of ideas would have indeed been at an extremely slow pace. Also, scientific and technological advance would have been less significant as compared to what we find it today.

The first sheet of paper ever made seems to have been in the year 105 A.D. The art of paper-making in principle has remained the same since then, but significant advance in the design and manufacture of plant and machinery had taken place over the time. Today, it is possible to make a sheet of paper 10 metre wide and continuously at a speed of 1000 m/min i.e. 60 km in length every house – roughly with the speed of a mail train. The daily production on a single machine can be as high as 1000 tonnes i.e. 50 wagon loads. There are various processes by which and various materials from which, papers of different grades are manufactured, basic classification of various processes being alkaline, acidic and mechanical. Then, there are as many others as can be made out by permutation and combination of these three. Likewise, conventional basic raw materials used in our country are bamboo, sabai grass and rags. Further, there are so many non-conventional secondary ones like hardwood, bagasse, agricultural residues, straw, linter, jute, hessian etc.

Sometimes paper is made only out of one raw material while many a time it is made from a mixture of different conventional or non-conventional raw materials or both.

The principal process followed in India is alkaline and the predominant raw material used is bamboo. For this reason, in this short note a brief description of process is given covering these two only.

Bamboo, after felling them in the forests are cut into strandard lengths of 2 to 2.5 m, made into bundles of 20 pieces each and transported to a paper mill by road or rail. At the factory these bundles are first given a water-wash and then fed into chippers wherein they get reduced to small pieces of size 2 to 3 cm. If need be, the chips are given another wash. Washed chips are then loaded into a digester – a cylinderical pressure vessel, along with alkali solution prepared separately. The digester lid is then closed and the contents subjected to steaming for a period of about 4 hours. Ratio of alkali to raw material being 1 : 4.5 : liquor to solids 4 : 1 pressure at 8 atm. and temperature at 160°C. After cooking, the pulp as it is now called, is blown out, screened and washed. The spent liquor coming out of washer is sent for chemical recovery to evaporators for concentration and then to furnace for burning it into sodium carbonate which later on is processed with lime in recausaticising plant for caustic soda recovery. The washed pulp is again screened to remove uncooked or half-cooked stuff as well as foreign material, and then sent for bleaching. Bleaching process consists of 3-4 or more stages for treating unbleached pulp with chlorine, alkali and hypochlorite in that sequence. At a later stage, at times, it is treated with other oxidising or reducing agents. The main function of bleaching is to make brown pulp white by removing out of it all colouring matter. For efficient performance during bleaching, intermediate wash is given after every stage of treatment. Total chlorine consumption comes to 10 to 12 per cent and alkali, 2 per cent on pulp during bleaching process.

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* Based on a lecture delivered by the late P.S. Kothari at the Indian National Science Academy, Delhi, on 1 February 1975.

** Late Shri P.S. Kothari was an outstanding expert in Paper Industry. He wrote a number of technical papers in the field. He also served as Industrial Advisor to Government of India. The 4th International Conference on Pulp and Paper Industry held at New Delhi in 2000 honoured him with Octogenarian Award.

Thereafter, the bleached pulp thickened to a consistency of 4-5 per cent is sent to refining. Refining is a very important function in paper-making. The pulp fibres are subjected to cutting, brushing and fibrillation actions, thus making it suitable for manufacturing the desired grade of paper during subsequent operations. The refining treatment is often given by installing a number of refiners in series. A refiner is an equipment wherein pulp is passed between two sets of hard metal bars – one set remaining stationery and the second one rubbing over the first. It is also necessary at this stage, either before refining or after, to add required amount of dyes, sizing chemicals and other materials to impart predetermined physical properties to a sheet of paper. It is also obligatory to know what substance of paper would be made of it. The stock as it is now called is finally screened at a very low consistency of about 1-0.5 per cent and then sent to the head-box of a paper machine.

The paper machine for the manufacture of common grades of paper for wiring and printing, consists of a wire-part, a couple of presses, a good number of drying cylinders, a couple of callender stacks and pope-reeler.

The fourdriner part mainly comprises an endless metal screen running over a good number of rolls of different diameters and make. When the stuff is received on the wire-screen most of the water drains down and most of the pulp fibres remain over it. These fibres, by certain operational techniques, are continuously made to spread evenly over the whole width of the wire. Well-felted fibres at the other end of the wire is called wet-sheet of paper and contains about 87 per cent of moisture when passed on to presses. The presses mainly comprise one bottom rubber roll and another metal top roll. The wet sheet is subjected to high pressure while passing through the nip of these rolls along with the woollen felt, thereby further water is squeezed out.

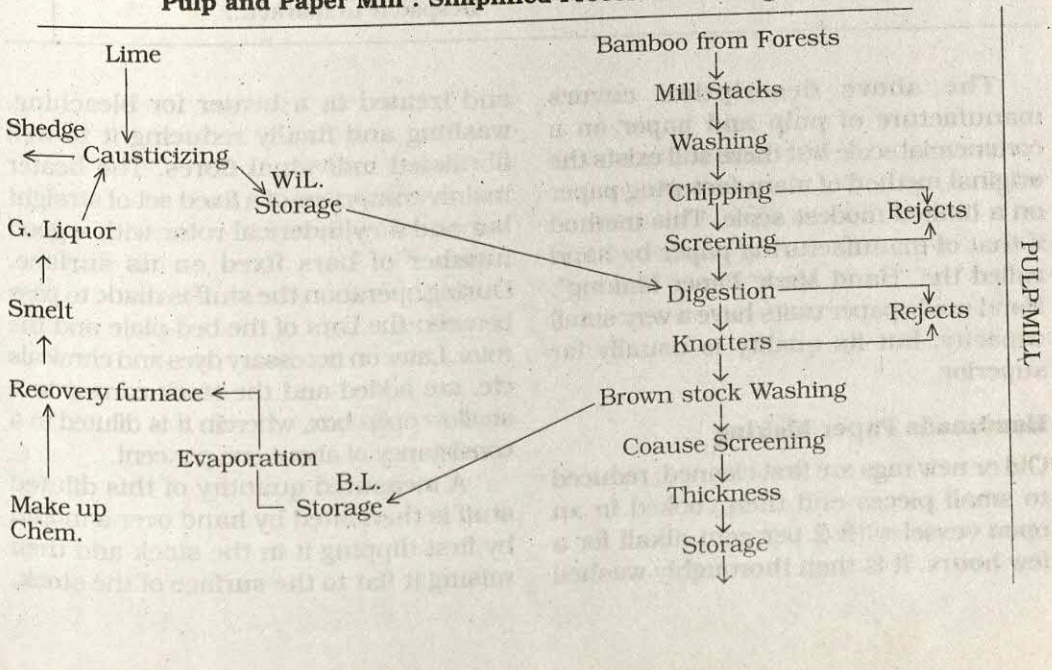
After the last press, the wet sheet containing about 65 per cent moisture is sent to dryer section, which consists of a number of cylinders, which help in drying the paper. Steam is injected into the cylinders and paper is passed around on the outer surface. Thus, the hot surface of the cylinders make the water of the sheet get evaporated. By the time paper leaves the last dryer its moisture content gets reduced to around 4 per cent. Paper so dried is then passed through a number of nips of calender stacks, which consist of a few chilled iron rolls. The calendering process is more or less similar to ironing of cloth and thus the paper surface is made smooth. The continuous sheet of paper thereafter is made to roll into rolls on the pope-reeler.

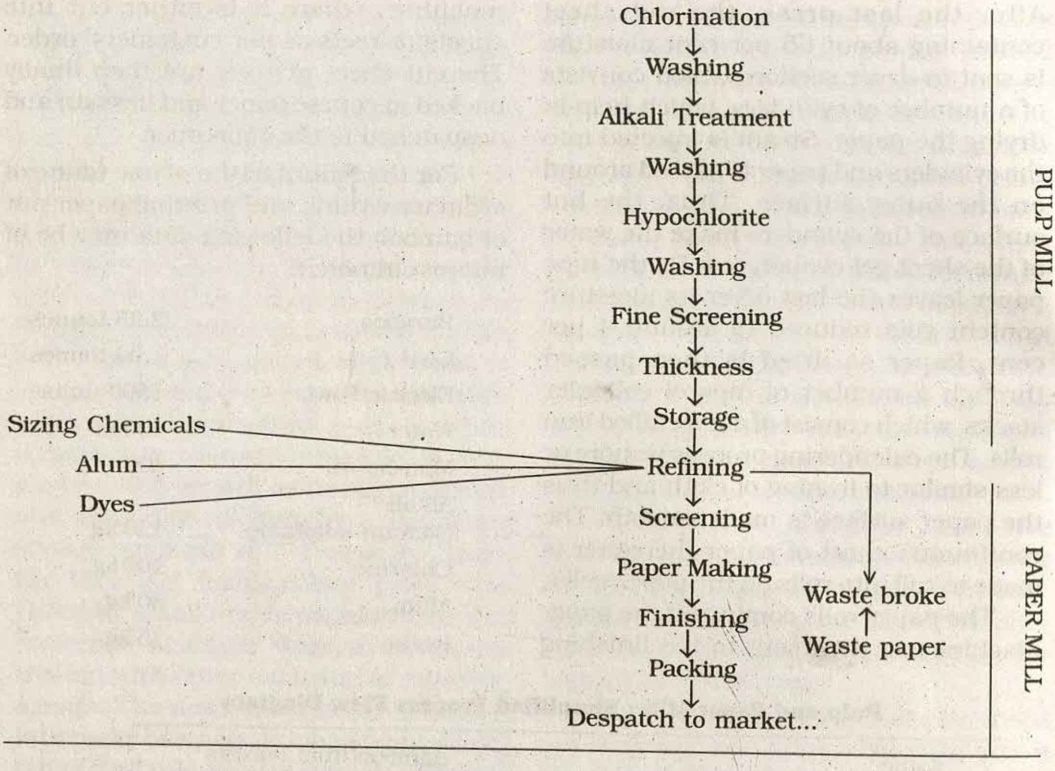
The paper rolls coming off the paper machine are then sent to the finishing machines where it is either cut into sheets or reels as per customers' order. The cut sheet or reels are then finally packed in course paper and hessian and despatched to the consumer.

For the manufacture of one tonne of ordinary writing and printing paper out of bamboo the following data may be of interest to note :

Bamboo	2.25 tonnes
Coal	1.00 tonnes
Electric Power	1500 units
Water	400 m^3
Man-hours	400
Alkali (sodium sulphate)	120 kg
Chlorine	100 kg
Alum	50 kg
Resin	15 kg

Pulp and Paper Mill : Simplified Process Flow Diagram





The above description covers manufacture of pulp and paper on a commercial scale but there still exists the original method of manufacturing paper on a limited modest scale. This method if that of manufacturing paper by hand called the "Hand Made Paper Making". Hand made paper units have a very small capacity, but its quality is usually far superior.

Handmade Paper Making

Old or new rags are first cleaned, reduced to small pieces and then cooked in an open vessel with 2 per cent alkali for a few hours. It is then thoroughly washed and treated in a beater for bleaching, washing and finally reducing it to well fibrillated individual fibres. The beater mainly comprises of a fixed set of straight bar and a cylinderical rotor with a good number of bars fixed on its surface. During operation the stuff is made to pass between the bars of the bed-plate and the rotor. Later on necessary dyes and chmicals etc. are added and the stock carried to a shallow open box, wherein it is diluted to a consistancy of about one per cent.

A measured quantity of this diluted stuff is then lifted by hand over a mould by first dipping it in the stock and then raising it flat to the surface of the stock.

Before the mould is removed away it is given certain jerks by hand to make the fibres spread evenly on the mould. The mould consists of a wooden frame with a wire screen on one side and supporting ribs fixed to the frame under the wires. Then there is a deckle i.e. a shallow wooden frame which is placed tightly over the sieve when stock is lifted over it.

The paper sheets made over the sieve are stacked in a pile and pressed for some time to extract water. The pressed sheets are then individually lifted and sticked on a smooth wall where they are allowed to stay till fully dry. The dried sheets are then peeled off the wall and well cooked starch solution is applied on both the sides and again made to dry in air by hanging them on a fine string. Thereafter the sheets are placed on a wooden plank and rubbed with a very smooth stone or a wooden block to impart high glaze, first on one side and then on the other. These sheets are now ready to write on and are packed and sent to market, for people to use.

Acid Rain – Causes, Effects and Control Measures

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EVEN BEFORE the advent of industrial revolution, the rains were always mildly acidic in nature. The Present term "Acid Rain" resolute the additional aciditly loaded in the rains due to the presence of acidic gases in the atmosphere as a consequence of rapid urbanization and industrialization. Acid rain refers to all types of precipitation that are acidic in nature. More precisely, acid rains are termed as Acid Deposition, which has been classified into Wet and Dry deposition. Wet deposition refers to rain, snow, sleet hail and fog which are acidic in nature, whereas dry deposition refers to acidic gases and particles. Acidity is measured in terms of pH scale, in which each unit of pH less than 7.0 represents a tenfold increase in acid concentration over the previous unit. Unlike the developed western countries, India is well below the critical levels today for realizing the threat of acid rain disaster. But with the ever increasing energy demand and dependence on coal as a major source of energy, the day will not be too far to witness the harmful impacts of acid rain.

Causes of acid rain

Scientists have confirmed that sulphur dioxide (SO_2) and oxides of nitrogen are the primary causes of acid rain. Burning of fossil fuels for power generation is a major contribution of SO_2 to the atmosphere. Industrial processes like smelting of sulphide ores, particularly of lead, zinc and copper also causes an increase in the SO_2 countent of the atmosphere. SO_2 can also be discharged into the atmosphere by the natural sources like volcanic eruptions, oceans (dimethyl sulphide), biological decay and forest fires. Majority of acidity in the rain attributes from the reaction of sulphur dioxide with the hydrogen per oxide in clouds, producing sulphuric acid. The hydrogen peroxide is formed due to the atmospheric photochemical reactions of volatile organic compounds from industrial and vehicular emissions.

The complexities of acidic deposition can be summarised as below:

Formation of H_2SO_4

$$SO_2 + h\upsilon \rightarrow SO_2$$

$$SO_2 + O_2 \rightarrow SO_3 + [O]$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Similarly, the formation of nitric acid is —

$$NO_x + H_2O \rightarrow HNO_3$$

Effects of Acid Rain

Acid deposition can affect the environment in several ways: It can affect aquatic ecosystems by lowering the pH. However not all aquatic ecosystems are affected equally. Some minor impacts on vegetation, forest cover, building materials and human health have been qualitatively identified but not quantified.

Effects on Lakes and Streams

The plants that grow in streams, ponds or lakes and exist on bedrock or sediments rich in calcium and or magnesium are naturally buffered from the effects of acid deposition. Aquatic ecosystems on neutral or acidic bedrock are normally very sensitive to acid deposition because they lack basic compounds that buffer acidification. One of the most obvious effects of aquatic acidification is the decline in fish population. In the middle latitude regions many acidified aquatic ecosystems experience a phenomenon known as "acid shock".

Effects on Vegetation and Forests

The severity of the impact of acid deposition on vegetation is greatly dependent on the type of soil.

- Increasing acidity results in the leaching of several important plant nutrients, including calcium, potassium and magnesium. Reductions in the availability of these nutrients cause a decline in plant growth rates.
- Acid deposition can cause direct damage to the foliage on plants especially when the precipitation is in the form of fog.
- Dry deposition of SO_2 and NO_2 has been found to affect the ability of leaves to retion water when they are under water stress.
- Acidic deposition can leach nutrients from the plant tissues weakening their structure.

Effects on Human Health

Acid deposition can influence human health in many ways.

Toxic metals, such as mercury and aluminum can be released into the environment through the acidification of soils. These toxic metals can end up in the drinking water, crops and fish which have specially toxic effects on human health. Specially the metal, alumimum is believed to be related to the occurrence of Alzheimer's disease in human beings.

The sulphuric acid in the rain can react with alkaline compounds like ammonia and calcium oxides in the air to form ammonium sulphate and calcium sulphate. These compounds together with other particulates and aerosols, at high relative humidity levels can produce haze and affect the visibility.

Research on children from communities that receive a high amount of acidic deposition showed increased frequencies of chest colds, allergies and coughs.

Effects on Man Made Materials

Acid rain not only damage the natural ecosystems but also manmade materials and structures. Marble, limestone and sandstone can easily be affected by acid rain. Metals (like galvanized steel) surface coatings, textile materials and ceramics can be effortlessly corroded by acid rain. Although man made materials slowly disintegrate even when exposed to unpolluted rain, but acid rain can influence the deterioration process substantially. Acid rain causes carvings of momments in stones to lose their features. The marble of Taj Mahal has been reported to be affected by SO_2 emission. The Statue of Liberty. The Canadian parliament Building in Ottawa, Egypt's temples of Karnak have been found to be affected by acid deposition.

Controlling the acid Rain

The best overall solution to the problem of acid rain is to reduce the emission of SO_2 and NO_2 at the source by reducing the use of fossil fuels and turning to alternate green fuels.

Installing appropriate de sulphurisation plants for controlling the SO_2 emissions from various sources.

Using alternative power sources like nuclear energy, solar power, and wind and water energy in power plants reduce SO_2 and NO_2 emissions to a large extent.

Though NO_2 emissions are more difficult to control due to the presence of nitrogen oxide in air which reacts with oxygen in high temperature furnaces, changes in the temperature of combustion can help reduce NO_2 emissions.

Scientists of State University, New York, USA have recommended the application of lime to entire water bodies including trees and forests during acid rain.

Conclusion

To solve the acid rain problem sustainably we must increase energy efficiency and reduce our dependence on fossil fuels by turning towards clean and green sources of alternate energy like Nuclear, Solar and Wind energy. Recognising the importance of these alternative measures, several countries including Germany, Norway and Sweden are actively involved in developing alternative sources of fuel energy and increasing the efficiency of plants which use fossil fuels.

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Hazards of Chemicals Used in Organic Qualitative Analysis

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SEEING IS BELIEVING for most of us. This presumably prompts us for the culmination of idea of practicals, which provide direct proofs to support theories, models or explanations. Laboratory study of chemical samples provide a considerable amount of data which gives us an insight into the process responsible for its formation and subsequent exploration of its properties. In order to achieve the goal of understanding the concepts through practicals, it is necessary to ensure efficient and judicious use of chemicals vis-a-vis to ensure the safety of laboratory environment and personal health hazard as well.

Concerns over better environmental[1] protection and discussions on more efficient ways to conduct chemistry experiments present more challenges today than ever. This has led to the promotion of world wide research into green chemistry where the main goal is to prevent wastage of chemicals at the source by designing and developing experimental processes that minimise the use and generation of hazardous materials.

Experiments[2] in organic chemistry, like identification of functional groups and synthesis of organic compounds, comprise a large number of practicals at higher secondary level in which a sizeable share of chemicals is consumed in the Laboratory. The unhealthy fumes and gases evolved during such tests affect us in many ways and pose a major threat to our health. At this juncture precautionary measures and prior knowledge can prevent such unavoidable problems. Hazards associated with some common experiments and tests conducted in chemistry laboratory are discussed here to help students and teachers to take appropriate measures to minimize the possible effects on human health.

Esterification Test (for Alcohols)

Alcohols react with organic acids (e.g. CH_3COOH) in the presence of an acid, say, hydrochloric or sulphuric acid, to form sweet smelling ester.

$$\underset{\text{(alcohol)}}{R-OH} + R'-CO-OH \xrightarrow[\text{(acid)}]{H+} R\text{–}CO\text{-}\underset{\text{(ester)}}{OR}+H_2O$$

The process of esterification involves warming of acetic acid and alcohol (e.g. ethyl alcohol) with the addition of a few drops of concentrated H_2SO_4. Heating the reaction mixture directly in flame, may burst the reaction vessel resulting in heavy casualties. Both ethyl alcohol and acetic acid are inflammable substances, the former being more inflammable than the latter.

Ethyl alcohol (C_2H_5OH) is a colourless liquid having boiling point 78.5° C and freezing point −114° C, its vapour and mist irritates the eyes, mucous membrane and upper respiratory tract. Also, it may cause eye damage, nausea, dizziness, headache and depression of central nervous system. A prolonged exposure to its vapour may lead to liver, kidney and heart damage.

Acetic acid (glacial) is a colourless combustible liquid (or solid below room temperature) with pungent odour having vapour pressure 12 torr (at 20° C), melting point (mp) 16° C, boiling point (bp) 118° C and flash point[3] 40° C, respectively. Its principal targets are eye, skin and respiratory system. It can react with bases and oxidising agents and these reactions are highly exothermic and violent in nature. Being much denser than air, vapours of acetic acid can remain suspended in air close to the surface for a long period. Tissue destruction of eys, skin or mucous membranes with pain, stinging sensation, coughing, sore throat, difficulty in breathing (if inhaled) are some of its typical symptoms.

Precaution

(1) Put the stopper of acid and alcohol bottles immediately just after use.

(2) Avoid direct heating of acids/ alcohols in flame.

Libermann's Test (For Phenols)

Add sodium nitrite solution to the solution of phenol dissolved in concentrated sulphuric acid, appearance of red colour indicates the present of phenol. The colour changes to blue or green by addition of a strong alkali, which further confirms the presence of phenol. A schematic view of above change can be represented as:

C_6H_5OH $NaNO_2$ $ON(C_6H_4)OH$ (P-nitrosophenol)
$ON(C_6H_4)OH + C_6H_5OH \rightarrow OH\text{-}C_6H_4\text{-}N = C_6H_4O$
alkali indophenol(red) $Na + O\text{-}C_6H_4 = C_6H_4O$
indophenol(blue)

During this test when phenol is heated with $NaNO_2$, heating should not continue for more than one minute as prolonged heating can produce fumes which can affect lungs. Phenol (or hydroxybenzene) is colourless crystalline solid having bp. 182° C, mp. 41° C, and inflammable in nature. It is a violent poison when taken orally and produces painful blisters in contact with skin.

On the other hand H_2SO_4 (or oil of vitriol) is a colourless, oily hygroscopic, highly toxic and viscous liquid. It can affect eye, skin, teeth and respiratory system[4] severly. With water and bases, it reacts violently and liberates huge amount of heat. Oxidizing agents like parmanganates, chlorates and fulminates reacts violently with it. The exposure of the acid basically manifested in the form of sour taste in mouth, lung edema (on prolonged inhalation), sore throat, abdominal pain, breathing problem etc. are a few to name.

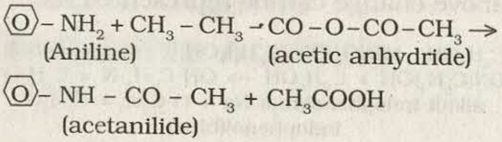
Precaution

(1) Addition of concentrated H_2SO_4 should be done at cold condition.

(2) Avoid body contact with phenol.

Synthesis of Acetanilide

Acentanilide can be prepared in the laboratory by acetylating aniline with acetic anhydride in presence of acetic acid (glacial).



– NH2 + CH3 – CH3 → CO – O – CO – CH3 →
(Aniline)
(acetic anhydride)
– NH – CO – CH3 + CH3COOH
(acetanilide)

The synthesis involves refluxing of reaction mixture containing $(CH_3CO)_2$, CH_3COOH and $C_6H_5NH_2$ for about half an hour. But it has been noticed that students often heat the reaction mixture directly in the flame of Bunsen Burner which ultimately leads to production of toxic fumes that pose a threat to skin and eyes and causes breathing problem to asthma patient.

Acetic anhydride (AC_2O) is moderatly flammable[5], highly toxic liquid with pungent odour, with b.p. 140° C and m.p. –73° C. It is incompatible with water, alcohol, and oxidizing agents as it can be violent and is exacerbated in the presence of acid or higher temperature. Primarily it can cause symptoms like sore throat, coughing, suffocation (if inhaled) and inflammation, watering of eyes (tears), redness, pain, blurred vision in eyes, womitting, diarrhoea etc. on acute exposure.

Similarly, aniline ($C_6H_5NH_2$) is a moderately flammable colourless toxic liquid having b.p. 184° C, mp. –6° C and specific gravity 1.022 (at 20° C). It can react with acetic anhydride, chlorosulphonic acid, nitrobenzene, glycerine, oleum, sulphonic acid thereby resulting hazardous outcomes, e.g. a mixture of nitrobenzene, glycerine and aniline can blow out the reaction vessel and mixture of aniline with acetic anhydride in a closed vessel can cause the temperature and pressure to increase. Aniline penetrates[6] through skin and is highly poisonous.

Precautions

(1) Prolonged heating and excess use of acetic anhydride are not advisable.

(2) Aniline should be kept out of contact with nitric acid and hydrogen peroxide.

Baudouin Test (For Oils)

Generally this test is used to distinguish vanaspati ghee from desi ghee (clarified butter) as the former contains sesame oil. When the sample is mixed with 5 ml of concentrated HCl acid and few drops of 2% furfural solution, in rectified spirit in a test tube, rose red colour appears on standing for 5-10 minutes. Special care need be taken while dealing with concentrated HCl (36% approx. or murilic acid[7]) as it is a highly toxic, colourless, fuming liquid with a sharp, pungent odour and may possess vapour pressure upto 215 torr (at 20° C). It is a strong corrosive acid which reacts with bases, oxidizing agents, most metals and affects organs like eye, skin and respiratory system. The vapour of HCl is corrosive and denser than air, so it can travel longer distance. The vapour concentration greater than or equal to 50 ppm is considered as dangerous to life and health.

Precaution : HCl should be kept out of contact with NH_3 as it can cause toxic NH_4Cl fume.

Steps to a Safer Laboratory

(1) Don't work alone in laboratory and never work without prior knowledge of a staff member.

(2) Consider all chemicals to be hazardous unless your are instructed otherwise.

(3) When conducting experiments with hazardous chemicals ask yourself these questions

- What chemicals am I using?
- What are the hazards and how shall I deal with them?
- What are the worst possible things that could happen if something goes wrong?
- What are the prudent practices, protection facilities and equipment necessary to minimise the risk of exposure to the hazards.

(4) Don't smell the fumes or vapours directly for testing odours, keep the flask at a certain distance from face. Fan the vapour towards you by hand, if smelling it is a must.

(5) Heat organic compounds in a sand bath, water bath or heating mantle only, but not directly in a flame or a hot plate.

(6) Don't put incompatible chemicals like Acids-Bases, Fuels-Oxidisers together on the shelf or working table.

(7) Don't store chemicals like CH_3COOH – CH_3CHO (on mixing they may ploymerise resulting huge quantity of heat), $(CH_3CO)_2O$ – CH_3CHO (reaction can be violent and explosive) close together at one place as they react easily with each other.

(8) Know the significance of the symbols printed on the chemical bottle and carefully read the instructions twice before taking anything from the bottle. For instance, if the symbol is:

- Explosive – Don't knock, friction, spark, heat it.
- Toxic – Avoid contact with human body.
- Harmful – Pay attention to substance having carcinogenic or mutagenic effect.
- Flammable – Keep away from naked flames, sparks, sources of heat.
- Corrosive – Avoid contact with eyes, skin, clothes.
- Irritating – Don't inhale vapours.
- Dangerous for environment – Destroy them before discharging the waste. Don't allow to enter sewage system.
- Radioactive – Avoid contact with human body and store it properly.
- Red colour mark symbolises fire danger, yellow indicates reactivity danger, blue represents health hazards and white signifies specific hazards like oxidizers, acids, bases or corrosive materials.

(9) Don't allow the experiments unattended at any cost.

(10) Excess reagents are never to be returned to stock bottle. If any such case arises, dispose of the excess.

Suggested Practice

(1) An unprepared student is a danger to him or herself and to others. Read experimental procedure prior to laboratory session.

(2) Plan an experiment well in advance and visualise yourself doing the experiment and ask yourself:
  - what will you need to test your hypothesis?
  - make notes about everything you will do while performing the experiment.
  - what other data will you need to collect?
  - what will happen if your attention is not focussed on what you are doing?

(3) Be economical in using chemicals.

Conclusion

Chemistry Laboratory can be a place of discovery and learning. However, by the very nature of the laboratory work, it can be a place of danger if proper common sense precautions are not taken. Students have to adhere to safety norms and instructions given by the teacher with a view that "only when you know the hazards, can you take the necessary precautionary measures."

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Significance of Laboratory Skill in Science Education

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IT IS A WELL-KNOWN fact that the acquisition of skills falls under the psychomotor domain of educational objectives and the development of skills requires practice, guidance and motivation. Development of psychomotor skills essentially involves muscular movements which are sometimes referred to as perceptual motor skills, as perceptions are instrumental to pre-requisites for motor skills. Psychomotor skills involve psychological processes apart from muscular movements with their overt effects. Psychological skill acquisition is mainly dependent on motivation of perceptual mechanism viz; sensation, interpretation, nervous system and the muscles involved.

Development of Psychomotor skill learning may mean learning an entirely new response pattern or chain like typing; or integrating previously learned pattern into a complex patterns or sequence like drawing; or improving and refining the skill for greater accuracy, speed and effect etc.

There are different ways of classification of motor skills and physical abilities. Some important physical abilities are as follows-strength (explosive, dynamic and static); flexibility, speed of change of direction, running speed; speed of limb movements; balance (static and dynamic of object); multi - limb co-ordination; gross body co-ordination and endurance (stamina). A broader classification would be eye-hand co-ordination; multi-limbed co-ordination; gross-body co-ordination; movement control; precision; response orientation, reaction-time; arm-movement speed; manual dexterity; rate control; finger dexterity; tweezer dexterity; arm-hand steadiness; wrist-finger speed; aiming etc.

Each skill has to be analysed in detail (i.e. clear task definition, description, what to do and how to do etc.). Further analysis (details of techniques, capabilities involved, timing and pacing, precautions, qualities to be achieved etc.) are necessary for understanding teaching learning of each skill.

Fitts (1969) has circumscribed three phases in skill learning viz cognitive, fixation and automation phase. In the **cognitive phase** learner gets to know adequately what is to be done, how it is to be done, why it should be done and why it should not be done etc. In this phase the learner is expected to attain a clear understanding of the component tasks, steps and sequences. The learner is expected to cognisize, often verbalise and intellectualize the task. **In the fixation phase** or organisation phase, the learner starts guided practice which should be useful. In this phase repetition is required, accuracy should be stressed from the beginning; component tasks may be practised separately, learnt adequately and then integrated into a chain or pattern. It is a phase where distributed practice / spaced repetition is better than massed practice; inhibiting factors like fatigue are to be avoided; feedback has to be provided- extrinsic by others and intrinsic by self. In this phase skill learning is characterised by four stages of rapid/steady progress with plateaus or periods of no perceptible progress in-between. Such stages can be anticipated, prepared for with greater motivation, better guidance and sincere efforts.

Automation or perfecting phase is where continuous and controlled practice makes the task performance increasingly automatic, smooth-working and perfect. It requires overt-learning i.e., practice beyond mastery level then it would tend to be automatic, involuntary, locked in and, mostly inflexible too unless deliberate efforts are made to refine it further and approximate it to perfection. It would then be characterised by increased speed, precision and elegance.

Since performance in higher secondary examination is a determining criterion for admission into medicine, engineering, for applied or basic courses, and even for vocational pursuits and skill deployment in day to day life; therefore, it is a must for students of higher secondary grade to develop sophistication in their abilities and understanding of scientific enquiry. It was necessary therefore to identify these difficulties in laboratory skills for contemplating improvement measures. The aim was to create a list of essential practical skills concerning laboratory tasks, which are subject specific, interdisciplinary and multi-disciplinary as also could be used later on in both pre- and in-service teacher education programmes.

Table 1: List of Practicals and Major Skills Envisaged

Sl. No.	*List of Practicals*	*Major Skills Envisaged*
1.	Use and care of compound microscope	Microscopy
2.	Observation of permanent slide of monocot stem	Observation
3.	Making T.S. of Dicot Stem and study of different tissues under microscope	Section–cutting and mounting
4.	To prepare temporary mount of onion root tip and to study various stages of mitosis.	Teasing and Mounting
5.	Preparation of reagents	Reagent preparation
6.	Test for sugar and albumin	Explanation (based on experimentation)
7.	Identification and description of China Rose	Description (based on observation)
8.	To study effect of temperature, pressure and solute concentration on osmotic movement of H_2O	Explanation

Methodology

A comprehensive analysis of procedures involved in laboratory exercises or practicals prescribed in Biology course of XII standard were carried out. To get diverse and wide range of data and to arrive at a realistic conclusion, three schools of Mysore City (all government schools—one central and the other two state government) where students were assigned the following practicals (as a part of their prescribed course) were selected (ref. Table 1).

Experimentation

The Institutions (schools) as mentioned before were selected based on similarity of school curricula, availability of infra-structure (mainly related to lab facility), students, teachers, student-teacher ratio, socio-economic status, co-education status and sex-ratio.

The practical skills were selected based on availability of infrastructure, lab facilities and lab materials and ease of execution of the practicals for a large number of students at a time.

Sub-skills of focusing and adjustment of stage, objective and eye piece were common to the skills of microscopy, observation, section-cutting and mounting. Sub-skill of sketching was common to microscopy, section-cutting and mounting and teasing and, mounting and experimentation. This shows that there are many common sub-skills essential for conducting diverse practicals viz., namely microscopy, observation, section cutting and mounting, teasing and mounting and experimentation. The practicals/activities were carried out on a sample of 80 students selected from three schools of Mysore.

Tool Construction

Skills, sub-skills and criterion measures were identified by critically going through the minute details of the instructional methodology for each experiment. Out of the tools, two were constructed by the investigation and the third was a standardised one (Raven, 1966).

Tool-1: Check-list for assessment of major skills

Check-lists for assessment of eight practical skills were constructed and scoring keys were used together by the investigators to generate the data (scoring keys were prepared based on the check-lists). If a student was able to attain successfully a particular skill during the course of a practical, it was marked as correct (O). Each right response was equal to one mark. If a skill is not attained, a cross mark (×) was put. Thus the cross mark is an indicator of levels of difficulties in skills.

Difficulties in lab skills were analysed during the practical classes, with the help of criteria measures presented in the check-list and the scoring was done on the scoring key sheets. Based on the scores, the skills were assessed and the data subjected to statistical analysis.

Tool-2: Diagnostic Test for eight practical skills

These represent and cover the entire area of content pertaining to each practical. Care was taken to see that the items of the test are appropriate and up to the level of the students being dealt with. Due weightage was given to different types of questions like match the following, true or false etc, fill up the blanks and tick the correct answer and the like etc. The test papers were evaluated with the help of answer keys and the scores were assigned to each student based on his / her performance.

Tool-3: Standard Progressive Matrices Test (Standardised)

To test the intelligence 'a standard progressive matrices Test' (Raven 1966) was administered for each student. The obtained scores were converted to percentage and final scoring done based on the guidelines given in the manual depending on the exact age of the student.

All the three sets of data based on the above three tools were analysed and compared school-wise. The difficulties exhibited by students in various skills and sub-skills were analysed qualitatively.

Eight experiments based on involvement of basic concepts and skills in Biology were selected from Class XII syllabus.

Results

I. Performance of students in different major skills (Data are presented in Tables 2 and 3).

Table 2 shows that description of China rose (Mean obtained Score (Mos.53.58%), teasing and mounting (Mos.72.28%); section-cutting and mounting (Mos. 75.11%) and microscopy (Mos.76.37%) were the skills in order of levels of difficulty and based on the mean of obtained scores in the 3 schools of Mysore. Relatively high scores (ranging from 92.29% to 83.81%) were observed in the skills of experimentation, preparation of reagents, explanation and observation, in that order, showing that these skills were easily attainable by the students of the three schools selected.

Students from those schools were found to be weak (poor) in practice skills involving description. This in turn is with

Table 2: Identification of difficult biology laboratory skills in higher secondary students of three schools

Sl. No.	*Major Skill*	*Obtained scores (%) in skill test*			
		CS-I	*SS-I*	*SS-II*	*Mean*
1	Microscopy	83.08	69.72	76.30	76.37
2	Observation	89.71	84.62	82.41	85.58
3	Section cutting and Mounting	79.29	74.45	71.59	75.11
4	Teasing and Mounting	79.38	67.21	70.26	72.28
5	Preparation of Reagents	86.07	84.69	86.07	85.61
6	Explanation	89.96	81.34	81.22	84.17
7	Description	58.00	51.97	50.63	53.58
8	Experimentation	92.29	84.97	83.81	87.02

regard to taxonomy practical on description of China rose. Average performance is observed in skills of microscopy, section cutting and mounting and teasing and mounting. By this we know that though the scores are high still there is scope for improvement. (Table 2).

Table 3 shows a categorisation of students based on a rating scale of percentage of students attaining marks in each skill into poor (0-20%), average (20-40%), good (40-60%) and excellent (60-80%).

Kendriya Vidyalaya I (Central School I) (CS-I) : Students are excellent in skills of explanation, experimentation, observation and preparation of reagents in that order. None fall under the category of poor attainment. A few (20%) are average to good in attainment of skills.

State School I) (SS-I) : Students (a majority) are excellent in observation,

Table 3: Categorisation of students based on their obtained scores in each skill

		No. of students under each category							
Institute	*Category*	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*
CS-I (Total Strength 24)	**Poor**	0	0	0	0	0	0	1	0
	Average	2	0	2	1	0	0	13	0
	Good	5	4	9	10	5	0	10	1
	Excellent	17	**20**	13	13	**19**	**24**	0	**23**
SS-I (Total Strength 29)	**Poor**	1	0	0	1	0	0	10	0
	Average	10	0	8	10	0	0	7	0
	Good	9	5	7	10	9	11	11	11
	Excellent	9	**24**	14	8	**20**	**18**	1	**18**
SS-II (Total Strength 27)	**Poor**	1	0	0	0	0	0	**14**	0
	Average	3	0	2	13	0	0	2	0
	Good	13	11	**22**	5	7	11	8	7
	Excellent	10	**16**	3	9	**20**	**16**	3	**20**
Total (Total Strength 80)	**Poor**	2	0	0	1	0	0	**25**	0
	Average	15	0	12	24	5	0	22	0
	Good	27	20	**38**	25	21	22	29	19
	Excellent	36	**60**	30	30	**59**	**58**	4	**61**

* S1-S8: Major skills 1-8

** Notation of scoring

Poor	(0.20%)
Average	(20-40%)
Good	(40-60%)
Excellent	(60 – 80%)

preparation of reagents, explanation and experimentation. All are well-up in observation, section cutting and mounting, preparation of reagents, explanation and experimentation (None show poor performance here). About 30% or so are good in most of the skills.

***State School II (SS-II)*:** A majority (88%) are good in the skill of section cutting and mounting while about (74%) show excellence in the skills of observation, preparation of reagents, explanation and experimentation. None are poor in attaining the skills S_2 S_3 S_4 S_5 S_6 and S_8 (viz., skills of observation, section cutting and mounting, teasing and mounting, preparation of reagents, explanation and experimentation).

If the student population of each school is taken into account the students can be categorised based on their performance (obtained score) into poor, average, good and excellent. In CS-I majority of the students show good performance in all the practicals, except the practical involving description (S7).

In SS-I and SS-II also most of the students fared badly in description skills.

Out of a total of 80 students, most of them are excellent in skills involving observation (75%), preparation of reagents (74%) explanation (73%) and experimentation (71%). About 50% of the students are good in section cutting and mounting. A maximum average of students (30%) were found to be good in teasing and mounting and many students were poor in description (Table 3).

II. Identification of Difficult Sub-skills in Different Major Skills

After the identification of difficult major skills, an attempt was made to identify the difficult sub-skills under each skill. A perusal of the results presented in Table 4 reveals that—

Under microscopy, 'focusing the slide' was found to be the most difficult sub-skill with 57% of the students showing difficulty and this is significantly higher when compared with other sub-skills. Use of diaphragm was found to be the next difficult sub-skill with 41% of the students showing difficulty. This was followed by sub-skills of 'mirror' light adjustment (36%), use of fine adjustment (35%) and sketching as seen under microscope (34%). Placement of slide and objective adjustment were found to be least difficult among the sub-skills of microscopy. *School wise* CS-I students have fared better than SS-II which in turn were followed by SS-I (Table 4).

Under the skill of observation listing out of diagnostic features was found to be the difficult sub-skill for 32% of students on the whole, with selection of a good slide (27%) and focusing (17.5%) being next in order. Stage adjustment was found to be the least difficult sub-skill with only about 5% students showing difficulty.

Under section-cutting and mounting, ability to remove excess stain was found to be the most difficult sub-skill with 44% of the students facing difficulty. The next in order are selection of good section and placement of slide (33%) and handling of razor and section cutting (31%).

Table 4: Identification of difficult sub-skills under different major skills.

Major skills		*Sub-skills*	*% of students showing difficulty in skill test*			
			CS-I	*SS-I*	*SS-II*	*Mean*
Microscopy S-1	1	Eye piece adjustment	11.11	17.74	12.44	14.42
	2	Objective Adjustment	1.15	1.45	1.62	1.31
	3	Use of diaphragm	29.36	**55.87**	37.26	41.35
	4	Mirror/ light adjustment	29.62	38.32	41.28	36.26
	5	Focusing the slide	**52.58**	**74.35**	43.19	**57.22**
	6	Placement of slide	0.90	0.00	0.00	0.00
	7	Use of fine adjustment	8.12	**48.24**	44.26	35.47
	8	Sketching as seen under the Microscopy	0.00	**52.02**	44.15	34.33
Observation S-2	1	Focusing	19.22	17.25	16.31	17.50
	2	Stage adjustment	4.20	5.00	5.00	4.70
	3	Scanning the slide	1.00	15.22	17.11	13.73
	4	Selection of good slides	24.39	**24.01**	**33.00**	**27.03**
	5	Use of pointer	2.99	11.24	11.21	8.80
	6	Highlighting a Section of T.S.	1.00	11.00	11.00	8.30
	7	Recognition	9.12	12.22	17.31	12.81
	8	Identification of section of monocot stem	2.14	13.24	17.42	10.91
	9	On diagnostic feature	**24.13**	**32.32**	**38.00**	**31.73**
Section-cutting and mounting	1	Handling of razor and other materials and section cutting	28.12	**33.31**	**32.25**	**31.22**
	2	Ability to keep section and to remove pith	4.12	14.25	11.31	10.22
	3	Selection of good section and placement of slide.	26.38	**37.62**	34.15	32.52
	4	Staining the section	14.07	15.26	21.27	16.76
	5	Ability to remove or wash excess stain	**37.52**	**39.75**	**53.72**	**43.85**
	6	Use of cover slips and Glycerine	6.02	10.25	13.62	10.25
	7	Focusing the slide	6.05	7.55	13.08	8.80
	8	Ability to sketching as seen under the Microscopy	10.22	17.82	9.00	12.52
Teasing and Mounting S-4	1	Preparation of Fixative	36.55	45.21	43.25	**42.52**
	2	Ability to use and handle Con.HCL	13.33	33.52	23.62	**23.25**
	3	Ability to wash, root	52.32	52.18	59.17	**54.62**
	4	Ability to use slide and stain	0.00	11.18	7.72	6.00
	5	Heating and use of spirit lamp	44.58	49.08	53.92	**49.25**
	6	Ability to squash	12.24	25.00	27.33	**21.51**
	7	Observation and identification of stages	0.00	10.00	13.52	6.92
	8	Sketching as seen under Microscope	0.00	12.25	11.52	8.00

Preparation of Reagents S-5	1	Use of Chemical Balance	**36.24**	**37.25**	**35.21**	**36.05**
	2	Accurate weighing of chemicals	27.24	24.21	**30.52**	**27.24**
	3	Use of measuring cylinder and pipette etc.	7.52	14.82	13.43	11.46
	4	Ability to mix & filter using filter paper	0.00	5.0	1.00	2.55
	5	Ability to stir constantly	0.00	0.00	0.00	0.00
	6	Knowledge of burner or hot plate use.	3.21	14.63	4.27	7.25
Explanation S-6	1	Use of Pipette	4.00	9.25	8.21	7.24
	2	Ability to use test tube holders	11.24	5.52	5.55	7.25
	3	Use of burner (Bunsen)	0.00	6.02	6.66	4.44
	4	Ability to distinguish colour changes	2.25	12.24	9.33	8.23
	5	Ability to infer	**35.27**	**71.25**	**72.52**	**61.27**
	6	Ability to mix with glass rods or by simple shaking	0.00	6.66	6.24	4.44
Description S-7	1	Classification Ability	**44.25**	**39.24**	**46.52**	**42.52**
	2	Habit and Habitat	11.21	11.24	13.25	11.11
	3	Finding root system	13.24	24.25	22.22	20.52
	4	Ability to find stem feature	15.37	24.82	26.82	19.43
	5	Identifying the type of leaf	**53.33**	**52.81**	**59.81**	**54.56**
	6	Identifying the type of inflorescence and flower	**58.24**	**59.52**	**62.31**	**60.05**
	7	Ability to distinguish Calyx and corolla	**56.21**	**59.21**	**59.44**	**58.81**
	8	Ability to distinguish Androecium, Gynoecium and fruit	**76.42**	**72.41**	**73.21**	**73.52**
	9	Knowledge of writing floral formula and diagram	6.66	**66.66**	**65.21**	**47.50**
Experimentation S-8	1	Knowledge of diffusion and osmosis	0.00	10.52	11.34	7.52
	2	Knowledge of membrane type	0.00	14.25	22.32	12.53
	3	Ability to handle the equipments	0.00	0.00	0.00	0.00
	4	Ability to record turgidity time	4.41	4.25	5.26	4.42
	5	Handling of thermometers	0.00	**28.25**	**22.26**	17.56
	6	Ability to know the effect of pressure on osmosis (i.e., Reasoning)	**29.52**	**47.24**	**43.21**	**40.21**
	7	Ability to make observation	0.00	16.24	20.04	12.05
	8	Ability to draw conclusions	**22.82**	**24.72**	**25.61**	**24.80**
	9	Ability to draw experimental diagram	**21.21**	**22.27**	**26.84**	**23.42**

Under teasing and mounting, ability to wash the root material was found to be the most difficult sub-skill with about 53% of the students showing difficulty. The next few sub-skills in order of difficulty were heating and use of spirit lamp (49%), followed by preparation of fixative (42.5%).

Under preparation of reagents, use of chemical balance was found to be the most difficult sub-skill with 36% students showing difficulty followed by accurate weighting of chemicals (27%).

Under explanation 61% students do not have inferring skills and was the most difficult sub-skill.

Description was the most difficult major skill identified and several sub-skills under this skill were found to be difficult for more than 50% students. The sub-skills are —

- ability to distinguish androecium, gynoecium and fruit (74%).
- identifying the type of inflorescence and flower (60%).
- ability to distinguish calyx and corolla (59%).
- identifying type of leaf (55%).

Under major skill of experimentation a maximum of 40% students have difficulty in reasoning i.e., ability to know the effect of pressure on osmosis. This is followed by ability to draw conclusions (25%) and ability to draw experimental diagrams (23%).

In the practical exercises involving microscopy, students of all the three schools have difficulty in the sub-skills of focusing slide. Almost half the students have difficulties in using diaphragm and drawing a sketch of the image as seen under the microscope. Mirror adjustment is also a skill which is not fully attained. More than 30% students have high level of difficulty in mentioning and listing out diagnostic features in the practical involving preparation of a permanent slide monocot stem. Selection of good slide also seems to be a difficult task for the students. Removal of excess stain, selection of good slide and placement of section on the slide, handling of razor are the skills encountered with difficulties in the practical exercise on study of T.S.of dicot stem. Washing of roots, use of spirit lamp, preparation of fixative and squashing are areas of difficulties in the practical on study of stages of mitosis in onion root tips. Use of chemical balance and weighing of chemicals are skills to be developed in the practical on preparation of reagents. Majority of the students seem to be lacking inferring skills in the practical involving test for sugar and albumin. Taxonomy seems to be a very difficult area for most of the students with as many as 6 sub-skills being poorly developed. The most difficult area seems to be the ability to distinguish androecium, gynoecium and fruits. Identification of type of inflorescence and flower also seems to be a difficult area for the students. Ability to distinguish calyx and corolla and ability to identify type of leaf needs improvement. Almost 50-70% of students show these difficulties. Reasonable amount of difficulty is encountered by about half the population of students in the ability to classify and writing floral formulae and diagrams. Forty per cent of the students on the whole show difficulty in reasoning skills. This involves understanding the effect of pressure on osmosis in the practical on effect of temperature, pressure and solute concentration on osmosis. In addition to this about 28% students show difficulty in drawing experimental diagrams and conclusions.

III. Relationship between Diagnostic Test Scores and Major Skill Test Scores

An attempt has been made to correlate the content knowledge and acquisition of skills pertaining to each practical.

Table 5 shows positive correlation between content knowledge and acquisition of skills pertaining to observation, teasing, and mounting, explanation and description of slides under a microscope in CS-I students. Correlation was significant in case of description since correlation coefficient value is 0.655368. A negative correlation was found in case of microscopy, section cutting and mounting, preparation of reagents and experimentation; therefore, none of these were significant.

The data obtained from SS-I further strengthens the correlation between content knowledge and acquisition of skills. Positive correlation between these two factors was found with respect to all the eight major skills. Significant correlation was established between D2-S2, D6-S6, D7-S7, D8-S8 where the correlation co-efficient value is more than 0.5 (Table 6).

SS-II data also confirm the positive co-relation between content knowledge and acquisition of skills (especially significant in case of D2-S2, D3-S3, D4-S4 and D8-S8) (Table 7).

These results have shown that with increase in content knowledge there is a positive build-up in acquisition of skills. In case of CS-I students, a positive correlation has been found between content knowledge and acquisition of skills of explanation and description. In case of SS-II students, there is high

Table 5: Correlation between Content knowledge (Diagnostic test) and acquisition of skills (Skill test) of CS-I students

Student No.	*Obtained scores*															
	D1	S1	D2	S2	D3	S3	D4	S4	D5	S5	D6	S6	D7	S7	D8	S8
1	50	71	67	99	86	59	61	83	79	74	83	95	59	50	69	92
2	94	86	87	99	86	99	61	87	93	74	98	95	88	72	98	92
3	72	93	67	99	98	64	72	67	79	91	98	86	47	61	69	96
4	83	86	98	97	86	86	72	83	86	83	98	95	88	67	94	85
5	83	57	80	87	86	68	61	87	79	99	98	99	88	67	87	99
6	50	99	60	93	86	91	61	92	86	83	67	86	88	58	94	88
7	44	93	67	77	71	91	72	79	79	83	83	86	88	64	87	96
8	61	86	67	77	71	86	72	62	64	83	67	82	76	56	69	96
9	78	86	98	93	86.	82	72	96	93	97	98	99	88	61	98	88
10	50	86	60	99	64	77	78	83	64	91	63	86	71	58	69	92

11	56	57	87	99	79	64	78	83	98	83	63	86	76	47	69	96
12	67	86	98	83	98	59	78	92	98	78	83	86	76	61	94	88
13	56	86	87	90	86	73	72	87	93	78	98	95	71	67	69	88
14	33	86	80	99	86	91	83	71	93	83	83	86	59	58	62	99
15	56	71	80	77	79	68	78	75	93	74	83	95	65	53	75	73
16	50	93	60	80	71	77	72	79	64	87	67	86	71	47	62	99
17	72	86	67	87	86	82	78	67	79	99	98	91	47	56	69	99
18	56	71	60	77	71	64	78	75	64	83	67	99	65	58	62	85
19	56	71	47	83	57	95	83	96	93	87	83	86	82	61	87	99
20	56	79	60	80	71	91	89	83	93	99	98	86	82	72	87	96
21	56	93	80	90	86	82	61	58	79	78	67	86	65	53	69	92
22	83	93	80	99	98	86	72	62	79	91	98	91	76	56	87	85
23	56	93	73	99	98	95	72	75	57	87	98	86	59	53	75	96
24	50	86	73	90	57	73	78	83	86	91	83	91	29	36	87	96
Corre.	0.06174		0.319149		0.11238		0.029273		-0.16114		0.415881		0.655365*		-0.1981	

D1-D8: Diagnostic tests 1-8 (ref. Tab.), S1-S8: Major skills 1-8 (ref. Tab. 1),
Corre.: Correlation co-efficient, *Significant value

Table 6: Correlation between Content knowledge (Diagnostic test) and acquisition of skills (Skill test) of SS-I students

Student	*Obtained scores*															
No.	D1	S1	D2	S2	D3	S3	D4	S4	D5	S5	D6	S6	D7	S7	D8	S8
1	50	57	69	87	64	77	83	67	71	91	92	86	47	58	56	92
2	44	57	50	80	50	59	78	46	36	78	75	68	47	25	37	73
3	56	99	87	90	57	86	78	67	57	87	83	86	59	83	56	92
4	44	57	50	83	50	50	67	58	36	78	50	77	53	42	37	77
5	62	86	56	90	62	82	78	83	57	87	83	95	59	58	37	92
6	75	86	87	99	57	82	78	86	57	91	75	95	71	58	44	92
7	75	57	87	90	71	82	83	86	57	96	98	99	71	69	44	88
8	37	50	56	87	50	59	78	54	43	65	75	68	59	22	37	73
9	75	71	62	80	57	82	83	79	50	91	75	86	59	69	37	92
10	75	71	87	93	79	54	83	83	43	96	92	91	82	58	56	92
11	25	50	56	70	50	54	67	54	21	83	33	73	9	28	31	77
12	37	36	75	83	50	77	72	46	21	74	75	77	59	39	31	69
13	62	86	81	77	64	82	78	42	29	83	83	82	47	22	37	77
14	31	50	56	77	50	83	56	50	21	70	50	77	41	47	31	77
15	69	71	87	99	57	82	78	79	36	96	83	86	71	75	25	88
16	69	79	75	90	57	82	94	75	43	87	98	86	71	75	62	96
17	44	86	44	83	57	77	78	83	29	87	83	86	59	58	37	88
18	81	79	62	83	64	77	83	67	64	96	83	91	65	72	62	96
19	69	50	56	73	50	59	67	54	43	74	75	73	53	25	31	73
20	75	93	62	83	57	77	78	86	43	87	83	82	59	69	37	92
21	69	79	56	87	50	82	78	54	29	83	67	68	59	31	25	65

22	56	79	94	87	57	82	78	75	29	99	83	86	76	69	94	92
23	44	86	75	87	50	77	67	83	29	91	83	86	59	75	31	92
24	69	86	56	99	57	82	72	83	29	91	83	91	65	75	82	96
25	62	71	56	80	50	86	72	50	36	65	75	64	47	17	50	81
26	56	86	56	80	50	59	67	71	29	74	75	64	47	33	31	77
27	75	50	69	80	64	82	78	71	43	99	83	82	82	75	82	96
28	56	64	69	80	50	91	61	79	36	87	75	86	65	61	50	96
29	44	50	50	77	50	55	56	38	29	70	50	68	47	19	25	73
Corre.	0.441826		0.503014*		0.150267		0.402935		0.400602		0.558104*		0.615492*		0.640325*	

D1-D8: Diagnostic tests 1-8 (ref. Tab.), S1-S8: Major skills 1-8 (ref. Tab. 1), Corre.: Correlation co-efficient, *Significant value

Table 7: Correlation between Content knowledge (Diagnostic test) and acquisition of skills (Skill test) of SS-II students

Student No.	*Obtained scores*															
	D1	S1	D2	S2	D3	S3	D4	S4	D5	S5	D6	S6	D7	S7	D8	S8
1	67	36	60	73	86	68	39	50	71	74	67	77	59	28	62	85
2	61	76	60	83	86	73	50	50	71	74	75	77	59	36	69	77
3	56	64	67	99	86	73	50	96	71	91	75	95	59	86	69	88
4	67	57	53	90	57	68	44	58	57	83	75	68	59	31	56	85
5	56	76	67	97	79	59	50	79	71	99	75	82	65	67	59	88
6	44	57	53	77	86	73	44	63	50	83	58	82	47	28	50	73
7	50	71	53	77	43	64	39	58	50	83	58	82	35	50	50	85
8	39	76	53	83	86	68	44	58	57	83	67	73	59	33	56	85
9	72	93	67	80	86	86	78	88	71	97	83	99	71	67	87	88
10	67	86	60	83	86	73	44	88	71	91	67	91	65	92	69	88
11	44	86	40	80	64	73	39	54	43	83	58	68	59	31	50	77
12	39	71	40	83	64	64	44	58	64	78	58	82	59	28	56	81
13	22	71	40	70	43	50	39	54	43	78	58	82	41	36	50	69
14	53	57	60	83	79	64	44	58	71	83	67	77	59	28	62	81
15	67	71	53	80	86	73	44	63	64	74	67	73	59	33	56	73
16	67	86	60	87	86	73	50	58	64	87	75	73	59	33	69	81
17	78	86	87	99	86	99	56	92	71	99	83	77	65	75	75	92
18	61	71	53	73	86	73	44	50	71	83	67	82	65	28	56	69
19	78	99	60	73	86	73	56	92	71	87	75	86	59	69	69	96
20	78	99	87	99	86	77	56	92	71	99	83	95	65	78	69	92
21	72	71	60	77	86	68	50	50	64	78	67	73	59	19	62	69
22	53	76	60	73	86	82	56	88	71	91	75	86	71	75	69	88
23	61	86	60	80	86	73	56	92	71	87	75	86	65	86	69	92
24	67	76	93	99	86	68	61	92	71	91	83	82	59	75	69	92
25	78	93	87	73	86	73	61	79	98	99	83	86	71	58	75	92
26	39	76	53	77	79	68	50	58	64	78	67	73	35	28	56	85
27	44	93	60	77	86	77	50	79	98	91	75	86	59	69	69	92
Corre.	0.284913		0.555329*		0.553634*		0.667493*		0.478291		0.389093		0.423485		0.608798*	

D1-D8: Diagnostic tests 1-8 (ref. Tab.), S1-S8: Major skills 1-8 (ref. Tab. 1), Corre.: Correlation co-efficient, *Significant value correlation between content knowledge and acquisition of skills of observation section cutting and mounting, teasing and mounting and experimentation. CS-I students show positive correlation between content knowledge and skill attainment. However SS-I and SS-II students show still higher correlation between theory and skill attainment.

IV. Relationships among Diagnostic Test Scores, Major skill Test Scores and Raw scores on SPMT

There is a positive correlation between content knowledge (Mean Diagnostic Test Score) and acquisition of skills (Mean Skill Test Score) by students of all the 3 schools and it was significant in case of SS-I (Co-coe. 0.7442) and SS-II (0.7002). CS-I students do not show a good correlation between content knowledge and acquisition of skills.

Also there seems to be a positive correlation between mental aptitude of the students and acquisition of skills by him / her. Though there is a negative

Table 8: Correlation of Skill tests (acquisition of skills) with Diagnostic tests (content knowledge) and SPMT (mental aptitude) of students.

Student No.	*CS-I*			*SS-I*			*SS-II*		
	MDT	*MST*	*SPMT*	*MDT*	*MST*	*SPMT*	*MDT*	*MST*	*SPMT*
1	69.25	77.88	52	66.50	76.88	51	63.88	61.38	45
2	88.13	88.00	57	52.13	60.75	42	66.38	68.25	48
3	75.25	82.13	53	66.63	86.25	53	66.63	86.50	51
4	88.13	85.25	55	48.38	65.25	47	58.50	67.50	45
5	82.75	82.88	56	61.75	84.13	51	65.25	80.88	50
6	74.00	86.25	51	68.00	86.13	54	54.00	67.00	45
7	73.88	83.63	53	73.25	83.38	56	47.25	71.25	28
8	68.38	78.50	55	54.38	59.75	47	57.63	69.88	49
9	88.88	87.75	51	62.25	81.25	52	76.88	87.25	54
10	64.88	84.00	51	74.63	79.75	59	66.13	86.50	51
11	75.75	76.88	55	36.50	61.13	30	49.63	69.00	35
12	86.50	79.13	53	52.50	62.63	44	53.00	68.13	37
13	79.00	83.00	54	60.13	68.88	47	42.00	63.75	13
14	72.38	84.13	53	42.00	66.38	32	61.88	66.38	40
15	76.13	73.25	52	63.25	84.50	52	62.00	67.50	43
16	64.63	81.00	50	71.13	83.75	56	66.25	72.25	49
17	74.50	83.38	48	53.88	81.00	52	75.13	89.88	53
18	65.38	76.50	57	70.50	82.63	54	62.88	66.13	40
19	73.50	84.75	59	55.50	60.13	41	69.25	84.38	51
20	79.50	85.75	57	61.75	83.63	50	74.38	91.38	52

21	70.38	79.00	52	54.13	68.63	48	65.00	63.13	47
22	84.13	82.88	51	70.88	83.63	56	67.63	82.38	50
23	73.50	85.50	48	54.75	84.63	51	67.88	85.25	52
24	67.88	80.75	57	64.13	87.88	53	73.63	84.38	52
25				56.00	64.25	50	79.88	81.63	55
26				51.38	68.00	48	55.38	67.88	42
27				72.0	79.38	55	67.63	83.00	51
28				57.75	80.50	51			
29				43.88	56.25	38			
Corre.	0.42		-0.0442	0.7447*		0.7724*	0.7002*		0.6328*

MDT- Mean diagnostic test, MST- Mean skill test, SPMT-Standard Progressive Matrices Test, Corre.- Correlation co-efficient, *Significant value

correlation between these two factors in case of CS-I, it is insignificant since the correlation co-efficient value is –0.0422. Moreover, there was strong positive and significant correlation between these two factors in case of both SS-I (correlation co-efficient 0.7724) and SS-II (correlation co-efficient 0.6328) (Table 8).

Discussions

An analysis of data recorded so far reveals that further research is required in the following areas (Table 9) to bring out remedial interventions as these are areas where students encountered difficulties in skill attainment.

Taxonomical skills of description seem to be difficult for all the students and this involves description and identification of various floral parts, writing of floral formulae and drawing of floral diagrams. Microscopical skills of focusing slide, using diaphragm and sketching from microscope also leave much to be desired. In the preparation of permanent slide of monocot stem, listing of diagnostic features and selection of a good slide seem to be difficult tasks. In the study of T.S. of dicot stem, skills of removal of excess stain, handling of the razor have not been perfected. Washing of roots, use of spirit lamp and preparation of fixatives in squashing techniques seem to be difficult skills in the study of mitosis in onion root tips. Inferring results in the sugar and albumin test, leaves much to be desired. The ability to reason out and understand the effect of pressure on osmosis is poor. Reasonable amount of difficulty is encountered in drawing diagrams of experimental set up and arriving at conclusions.

Contrary to this it may also be noted that data from Central School students shows that skill attainment could be independent of IQ as there is negative correlation. If mental aptitude test is taken as a criterion for measuring or understanding the role of IQ in skill attainments, then interestingly in case of Central School students, IQ does not

Table 9: Areas Requiring Further Studies

Sl. No.	*Practical*	*Skill*	*Subskill*	*%*
1.	Identification and description of China Rose	Description	Ability to distinguish Androecium, Gynoecium and Fruit	73.52
			Identifying the type of inflorescence and flower	60.05
			Ability to distinguish Calyx and corolla	58.81
			Identifying the type of leaf	54.56
			Classification Ability	42.52
2.	To prepare temporary mount of onion root tip to study various stages of Mitosis	Teasing and Mounting	Ability to wash, root	54.62
			Heating and use of spirit lamp	49.25
			Preparation of Fixative	42.52
3.	Making transverse sections of Dicot stem and study of different tissues under microscope	Section cutting and mounting	Ability to remove or wash excess stain	43.85
			Selection of good section and placement on slide.	32.52
			Handling of razor	31.22
4.	Use and care of compound microscope	Microscopy	Focusing the slide	57.22
5.	Test for Sugar and Albumin	Explanation	Ability to infer	61.27
6.	Observation of Permanent Slide of Monocot Stem	Observation	On diagnostic feature	31.73
7.	Preparation of Reagents	Preparation of Reagents	Use of Chemical Balance	36.05
8.	To study effect of temperature, pressure and solute concentration on osmotic movement of water	Experimentation	Ability to know the effect of pressure on osmosis (ie., Reasoning)	40.21

% of students having difficulty (Mean Value) seem to be playing a significant role in skill attainment.

Both SS-I and SS-II Schools show a high correlation between mental aptitude and acquisition of skills. What does it mean? Obviously, good IQ leads to skill attainment or conversely, lack of IQ could be an important reason for lack of attainment of specific skills. This being so because all the other requisite criteria of appropriate instructional methodology, infrastructure etc. for carrying out experiments have been met. Contrary to this it may also be noted that data from Central School students shows that skill attainment could be independent of IQ as there is negative correlation.

It may be noted here that it is the central school students who generally do well in competitive exams as compared to State School students. This perhaps explains the negative correlation obtained between IQ test and skill attainment of school students in the present study. It is obvious that there is more commitment at student-parent level to theory-oriented entrance exams. Parents want their children to perform well in the Board Exams and Entrance tests even if it requires sacrificing the acquisition of various psychomotor skills. It is so because entrance tests for professional courses do not include testing of psychomotor skills as these are confined only to judge the cognitive level of the students. Attainment of psychomotor skills thus, often gets neglected and the skill acquisition therefore becomes secondary. Schools too often do not lay desired emphasis on attainment of psychomotor skills neglecting laboratory tasks for various reasons. For example, the percentage of students of a particular school getting selected through the entrance tests gives a hype and credibility to the schools. Higher the percentage that gets through these competitive tests, higher the credibility. Quantity becomes an indicator of achievement. It is this attitude that is one of the deterrents in the schools in the attainment of skills.

Another contributory factor to the variations between central and state schools could be the factors like the school administration, profile of the teaching-learning community, infrastructure the evaluation methods, the socio-economic background of students, the school curricula, student-teacher ratio, co-educational status and sex-ratio, exposure of students to extra-curricular activities etc. These differ from urban to rural, and from central to state schools (NCERT, 1999).

It has already been stressed by the National Science Education Standards (National Research Council, 1996) and the Benchmarks for Science literacy (American Association for the Advancement of Science) *that students need to adopt methods used by active scientists.* How is this possible in the present situation where most of the tests are theory-oriented rather than skill-oriented? Tragically, even a newly appointed teacher does not have the basic skills to carry out common laboratory techniques or tasks. Teachers and laboratory assistants are raw and unskilled at the entry point on the job scene. He/She does not have adequate experience to plan and set up laboratory activities. This has been our observation as well. A lot of time is wasted and chaos sets in as they start the job in an untrained manner. They acquire the skills on the job, may be after putting in a few years of service. Skilled employees on the other hand are sidelined due to lack of a formal degree. All these are pointers to the place accorded to actual skills and expertise in our various educational curricula and job selection procedures.

Skill acquisition (or practical work or field work) is a truism that cannot be neglected. Practical skill is a combination of applied knowledge and manual technique wherein psychomotor aptitude becomes crucial. It is regrettable that the best of students, teachers and other employees (Mary Scotts, 2000) have good theoretical knowledge but lag behind in application of theory to practical problems and in development of skills to resolve the problems. With skill acquisition, our country can come up with more indigenous solutions to various problems. This would perhaps be an impetus to the best to hang on and even prevent brain-drain. We have the brains, the skills of memory, skills of intuition, skills of abstraction, but the actual skill of doing it is lacking. Skills of performance are lacking. Mary Scotts (2000) reports that even the best student solves problems involving trivial exercises algorithmically with little creativity or reasoning. How is this skill to be developed? Students lack conceptual understanding and laboratory process skills and are unable to transfer knowledge to real world settings. How is this to be set right but by emphasis on skill acquisition? And this can be achieved through actual lab work alone.

Expository laboratory work has been found to require little thought and has been likened to following directions to a cookbook. Majority of the lab texts have been found to appeal to the lowest three cognitive levels of knowledge, comprehension and application. None of the lab text activities required students to operate at the highest three cognitive levels of synthesis, analysis or evaluation. Higher order questions are not asked by students in the lab (Mary Scotts, 2000). With this in mind , four types of laboratory set -ups have already been suggested viz., expository, Inquiry-based, discovery-based and problem-based. This, if practised in our Indian school and college curricula would go a long way in skill acquisition at both the higher and lower levels of cognition. Inquiry-based laboratory programmes have been found to enhance student performance especially lab skills and skills of graphing and interpreting data. How is this possible in India where a number of schools even now lack lab infrastructural facilities for any subject (6th All India Educational Survey, 1999). How is science education, let alone skill development of the required type be possible in such a scenario?

The following suggestions can be made in the light of the above discussions:

(1) Entrance tests and competitive examinations should involve some practical work and testing in lab

skills. Entrance tests which are application oriented only on paper should have practical evaluation on skill attainment.

(2) Weightage to practicals and theory could be changed, be it applied or pure sciences with the emphasis shifting to practicals (60% weightage to practicals and 40% to theory could be an ideal starting point).

(3) Discovery-based, inquiry-based and problem-based laboratories should be set up in schools to cater to the higher levels of cognition.

Science education, keeping all the above parameters in mind would lead to skilled manpower development which in turn would help in pulling up a sagging economy. It would also bring National Standards of Science Education on par with International Standards. School science education becomes the foundation on which the pillars of skilled manpower of an advanced technological future rests . This skilled manpower and brainpower would provide the correct momentum and push to the developing economy of our country.

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Some Technological Advances That Will Shape the Future

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TECHNOLOGY has taken great strides over a span of last couple of years. The technological advancements made in material science has seen the development of new materials including smart materials which show weird properties. Great advances have also been witnessed in the field of nanotechnology. This is a new and totally novel technology likely to touch the life of common man in a big way. Even information technology (IT) is also going to benefit by nanotechnology. Indeed, today we are at the convergence of nano, bio and information technologies. In this article, we shall attempt to focus on some of the novel technological advances in the field of material science, information technology and robotics.

The weird behaviour of a new metallic compound has recently amazed material scientists. This material on being heated has a rare ability to shrink rather than expand, apparently defying the laws of physics. A blend of zirconium, tungsten and oxygen, the chemical name of the new material is zirconium tungstate.

The possibilities for commercial applications of the new material appear huge. It may help overcome serious problems in electronics, metallurgy and ceramics. In particular, in the field of electronics, this material may have important applications such as in the fabrication of high-quality silicon chips that are considered to be the back-bone of modern electronic circuitry.

In the telescopes and laser devices, materials with low thermal expansion properties are generally required so that the precise focussing is not disturbed by temperature fluctuations. Zirconium tungstate may come in handy in such optical applications, too.

The scientists working at the University of California have recently succeeded in developing materials with unique properties. Such materials will help create robots that could walk around the outside of a space vehicle inspecting it for damage, like that caused by missing heat-shield tiles or a holed wing in a space shuttle. Super-grip shoes for athletes and tyres that will hold the road better in all weathers are just a few other possibilities, which the development of these materials is going to offer. Even for stunt actors playing superheroes like Spiderman, it will be a cakewalk to climb walls and cruise across the ceiling without the studios resorting to computer graphics.

In fact, in the development of the bizarre material described above, the scientists have taken cue from gecko (house lizard). It may be mentioned that the hairs on a gecko feet, called setae, are the key to its remarkable grip on just about any surface, be it rough or smooth, wet or dry. The tips of the setae being sticky help the gecko to hang from a ceiling with its entire weight suspended from a single toe. The California scientists have now succeeded in making synthetic gecko hair. A material coated with these hair would work like a gecko's feet making amazing applications possible.

The fabrication of smart materials has been taking place for quite some time now. They are also found to play an important role in the development of smart buildings, smart computers, smart fabrics etc. In fact, work has been in progress on the development of smart cars. These cars will indeed be so smart that they will be able to recognise the parking space, reverse into it and automatically straighten the steering wheel.

The development of new technology for smart cars that was being done by the Hampshire-based radar research group, was revealed only about two years ago. The car, called Parking Assistant, combines information from radar sensors with visual data from an array of miniature cameras surrounding the car. It then manoevers itself into this space with minimum of fuss and botheration.

A Germany-based motor company is at present testing the revolutionary new technology. The company is researching to make the self-parking dream car afordable by replacing the radar technology with cheaper ultrasonic sensors and lasers.

Nanotubes are yet another example of facinating new materials that have been developed in recent past. Nanotubes are hollow cylindrical structures made of carbon atoms having a diameter of, typically, about a nanometre (one-billionth of a metre). They were first discovered by Sumio Ilijima at the N.E.C. Fundamental Research Laboratory of Japan in 1991.

Nanotubes have been used for fabricating transistors, diodes and nanowires. They have also been used for making field-effect transistors (FETs). The scientists at the IBM Corporation are now experimenting with nanotubes so that they could make them emit light. Such light-producing nanotubes could perhaps be used in the distant future for a quick exchange of more information between a microprocessor and a memory chip. This will ultimately pave the way for the development of faster and smaller computers.

In this age of information technology (IT), the words e-mail, e-commerce, e-book etc. are commonplace. Yu Chen and his team members at the E Ink Corporation in Cambridge, Massachusetts, USA, are now in the process of creating e-paper. However, they have so far only been successful in creating an ultra-thin electronic ink display screen. This flexible screen, which is just 0.03 centimetre thick (i.e., barely as thick as three human hair) can be bent, twisted and even rolled without distorting the text appearing on it. This will pave the way for electronic newspapers, wearable computer screens and smart identity cards. When fully developed, it will not only be able to display black and white but also colour text, using wireless technology. Buying the daily newspaper will no longer be necessary because with e-paper it will be updated wirelessly or through the Internet.

It is for the first time that such an electronic screen has been developed that can be flexed or folded. The video displays are, however, not possible to be obtained on the present screens because of the switching speed of the electronic ink. The display on the screen consists of two components. While the front part or component switches according to the electronic signals, the back component is a circuit comprising transistors that controls each individual pixels forming the display on the screen.

The current device developed by the researchers is too thick to be folded in half but Chen and his team members are working on a thinner version. However, the task is challenging indeed. "The real challenge", says Yu Chen, "is to have the transistors made on a very thin and flexible substrate". An e-paper will certainly change the face of publishing industry. Not only that, being saver of forests, it would be ecofriendly, too.

A high-tech e-nose, that can sniff out lung cancer, is also in the process of development. Eight sensors made of quartz crystal are being used in the process. Carrado Di Natale, the electronics expert associated with the development of the e-nose, says that the patients with lung cancer breathe out a variety of tell-tale compounds. Generally, alkanes and benzene derivatives, these compounds have distinctive smell of their own. An e-nose sniffing out these compounds can detect whether a person is suffering from lung cancer or not.

Cellphone is now an in-thing. The first cellphone was invented by Martin Cooper way back in 1973. It was far bulky and occupied much space. Weighing a little less than 1 kg, it was 25 cm in height, 8 cm deep and 4 cm wide. However, as already witnessed, in a short span of three decades since the invention of cellphone, its size has shrunk so much that it now practically fits into the users' palm.

Seventy-four-years old Cooper now dreams about the day when the technology will be so advanced that the cellphones will automatically dial out the number the user wishes to contact. It will be so much reduced in size that it will comfortably fit being the users' ear. Moreover, there will be facility in the state-of-the-art cellphone to notify the user of the incoming calls with a tickle instead of a ring. Cooper believes that the next big advancement in the wireless technology will be wide-area, high-speed accessability to the internet.

Ink-jet printers are used with the computers for taking the print-outs. It uses ink-filled cartridges. Coloured ink-jet printers use three cartridges, instead of one, each corresponding to one of the three primary colours. Ink-jet printers can be used in a limited manner for the desk-top publishing work, too. But, now the scientists at the University of California in Berkeley are exploring a totally new and revolutionary application of the ink-jet printers.

John Canny and his team members are embarking on the task of evolving a state-of-the-art technology that will enable ink-jet printers to produce fully assembled gadgets including electronic components. According to Canny, for circuit printing, conducting polymers may be used in the cartridges of the ink-jet printers. "The trick in the new technology is to print layer upon layer of conducting polymers in such a way that the circuitry the device requires is built up as part of the bodywork", says Canny.

In fact, the gameplan of the Berkeley scientists is to print a complete and fully assembled device rather than creating a casing and then filling it laboriously with electronic circuit boards, components and switches. But, there is a disadvantge, too. In case the component breaks it has to be thrown away as it cannot be fixed or replaced.

It may not be out of place to mention that due to the merging of flexible material with electronics, a new branch called **Flexonics** has come into being the spin-offs from which may be phenomenal. Moreover, this new and exciting branch is expected to offer endless possibilities holding the potential of shaping the future of mankind.

A Study of Correlation Between the Availability of Physics Laboratory Facilities in Higher Secondary Schools and Their Utilisations

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We have to live in a civilisation driven by science and technology whether we like it or not. Science is no longer confined to a few seriously devoted persons. Living effectively in the present world invariably warrants, to variable degrees, some basic knowledge of science. Teaching science to every individual has become an essential part of general education. All major branches of science have evolved through research, both theoretical and laboratory based, which are often complementary to each other. Science courses for school children are designed to provide the learners a feel for both i.e. the theory and practicals. Learning by doing is one of the cardinal principles of teaching science. Since laboratory work is an activity oriented exercise, students usually show more interest to do practical.

Physics Practicals and Attitude

Physics is a science dealing with physical aspects of nature and natural phenomena. In order to understand the nature and natural phenomena in the universe we should study physics. Physics practicals provide a mean to learn physics concepts by doing experiments. Physics practicals also enable the student to verify some aspect of theoretical concepts taught to them beside learning about scientific method, creating interest for research and preparing them for higher studies so as to ultimately prepare amongst them scientists for the country. Attitude means a state of mental and emotional readiness to react to situations, persons or things in a manner in harmony with the habitual pattern of response previously conditioned or associated with a given stimuli.

The Present Study

The availability and utilisation of physics laboratory facilities in the school determines, to a large extent, the understanding of the concepts learnt by the students. The laboratory facilities also help the students to get better prepared for pursuing academic as well as professional courses and also to develop positive attitude towards the subject. So here, the investigator tried to correlate the availability and utilisation of physics laboratory facilities in higher secondary schools and attitude of higher secondary students towards practicals.

Need for the Study

Acquiring scientific knowledge and scientific outlook, which are the two main objectives of teaching science, can be achieved to a large extent only through regular practical work in the laboratory. So practical work occupies very important place in our curriculum. A student should not only be a passive observer but an active worker, an enthusiastic experimenter and a discoverer. Physics practical provides the opportunities for the same. It is important to study the students' likes or dislikes about physics practicals. The effective accomplishment of physics practicals depends upon well mentioned and good quality equipment and utilisation of other sources. So there must be definite relationship between the laboratory facilities and students likes or dislikes for physics practicals.

So far not much research has been done regarding this aspect of physics practicals. So the investigators, endeavoured to study the correlation between physics laboratory facilities and attitude of higher secondary students towards physics practicals. It is, as felt by the authors, of paramount importance to study the correlation between the availability and utilisation of physics laboratory facilities in higher secondary schools and attitude of higher secondary students towards physics practicals. .

Objectives

(a) To find out the correlation between the availability and utilisation of physics labo.;atory facilities in higher secondary schools and attitude of higher secondary students towards physics practicals.

(b) To find out whether there is any significant difference in the attitude of higher secondary students towards physics practicals with respect to the variables:

- (i) Sex (boys and girls)
- (ii) Groups selected (Maths, Physics, Chemistry and Biology (MPCB), or Physics, Chemistry, Botany and Zoology (PCBZ).
- (iii) Language of instruction (Tamil and English).
- (iv) Locale (Rural and Urban).

(c) To find out whether there is any significant difference in the attitude of higher secondary students towards physics practicals with respect to the school variables

- (i) Types of management (Government, Private-aided and Self-financing)
- (ii) Nature of schools (Boys, girls and co-education).

(d) To find out whether there is any significant difference in the attitude of higher secondary students towards physics practicals with respect to the following family variables

- (i) Educational qualification of father
  (Illiterate/SSLC and below
  (Higher Secondary/Degree/
  Professional)

(ii) Occupation of father
(Coolie/Business/Clerk/Professional)

(iii) Educational qualification of mother
(Illiterate/SSLC and below Higher Secondary/Degree/Professional)

(iv) Occupation of mother
(Housewife/Coolie/others)

(v) Income of the family
(upto Rs.12,000 / Rs.12000 - Rs.60,000 / Above Rs.60,000)

(e) To find out whether there is any significant difference in the availability and utilisation of physics laboratory facilities among the higher secondary schools in Thoothukudi education district with respect to the variables.

(i) Types of management (Government, Private aided and Self-financing)

(ii) Nature of Schools (Boys, Girls and Co-education).

Methodology

(a) Methodology in Brief

The investigators in this study adopted the survey method of the research.

(b) Tools

1. 'Attitude scale' developed and standardised by the investigators was utilised to fmd out the attitudes of higher secondary students towards physics practicals.
2. 'Questionnaire' developed and standardised by the investigator was utilised to collect data regarding the availability and utilisation of physics laboratory facilities in higher secondary schools.

(c) Sample

The sample for the study comprised of 420 students studying in higher secondary schools. The investigator used random sampling technique. The samples were taken from 9 higher secondary schools in Thoothukudi education district.

(d) Variables

The investigators considered 11 variables for the study. They are sex, group, medium of instruction, type of school management, nature of school, location of the school, father's educational qualification, father's occupation, mother's educational qualification, mother's occupation and income of the family.

(e) Statistical Technique

The statistical techniques used for this study are

1. Percentage Analysis
2. CR-test
3. Rank-Difference correlation coefficient
4. χ^2-test
5. ANOVA test

(f) Limitations

1. The present study is limited to Thoothukudi educational district only.

2. The present study is conducted only on Class XII students learning physics as a subject.
3. Only 420 students taken from 9 higher secondary schools located in Thoothukudi educational district from the sample.
4. The duration of the study is also limited.

Findings

Table 1

School Number N	Attitude Mean Score X	Laboratory Facilities Score Y	Rank R_x	Rank R_y	Difference between Ranks Ds	Difference Squared D^2	$\rho = \frac{1-6\Sigma D^2}{N(N^2-1)}$
1.	66	189	1	1	0	0	0.925 (table value (0.783)
2.	61	153	7	7	0	0	
3.	64	156	5	6	1	1	
4.	65	159	4	5	1	1	
5.	66	176	1	2	1	1	
6.	53	150	9	9	0	0	
7.	61	151	7	8	1	1	
8.	66	169	1	3	2	4	
9.	64	163	5	4	1	1	

Since the calculated value of p (0.925) is greater than the table value of p (0.783) at 1 % level of significance, the correlation between attitude (X) and the laboratory facilities (Y) is found to be very high and positive.

It can be inferred from Table 2 that there is significant difference in the attitude of higher secondary students towards physics practicals with respect to the variables 'sex', 'group selected' and 'locale'. The performance of girls, MPCB students and rural students are found to be better than the performance of boys, PCPZ students and urban students respectively. It is also found that there is no significant difference in the attitude of higher secondary students towards physics practicals with respect to the variable 'language of instruction'.

It can be inferred from Table 3 that there is significant difference in the attitude of higher secondary students towards physics practicals with respect to the variables 'types of management' and 'nature of schools'. From the mean scores, it is inferred that the attitude of higher secondary students of government school is more positive that the attitude of higher secondary students of private aided and self-financing schools. It is also found that the attitude of higher secondary students of girls' schools is more positive than the attitude of higher secondary boys' schools and co-education schools.

Table 2

Sl. No.	*Variables*		*Statistical Technique*				*Result*
			No.	*Mean*	*S.D.*	*'CR' Value*	
1.	Sex	Boys	266	58.98	10.86	6.53 (table value = 2.59)	Significant at 1 % level
		Girls	154	65.07	8.09		
2.	Groups Selected	MPCB	304	62.12	10.61	3.133 (table value = 2.59)	Significant at 1 % level
		PCBZ	116	58.82	9.24		
3.	Language	Tamil	274	60.57	9.85	1.680 (table value = 1.97)	Not significant even at 5% level
		English	146	62.41	11.14		
4.	Locale	Rural	127	63.99	6.59	4.48 (table value = 2.59)	Significant at 1 % level
		Urban	293	60.01	11.41		

Table 3

S. No.	*Variables*	*Source of Variation*	*Df*	*Sum of Squares*	*Mean square variation*	*'f'- Value*	*Result*
1.	Types of Management	Between the groups	2	4878.13	2439.06	25.29 (table value = 4.66)	Significant at 1% level
		Within the groups	417	40212.63	96.43		
2.	Nature of Schools	Between the groups	2	5153.50	2576.75	26.90 (table value = 4.66)	Significant at 1% level
		Within the groups	417	39937.25	95.77		

It can be inferred from the table that there is significant difference in the attitude of higher secondary students towards physics practicals with respect to the variables 'educational qualification of father', 'occupation of father' 'educational qualification of mother' and 'income of the family'. It is also found that there is significant difference in the attitude of higher secondary students towards physics practicals with respect to the variable 'occupation of mother'.

Table 4

Sl.No.	Variables	χ^2 -value	Table Value	df	Result
1.	Education of father	5.20	15.507	8	NS
2.	Occupation of father	7.64	12.592	6	NS
3.	Education of mother	0.60	12.592	6	NS
4.	Occupation of mother	20.26	9.488	4	S
5.	Income of the Family	7.88	9.488	4	NS

Table 5

Sl. No.	Variables	Source of Variation	Df	Sum of Squares	Mean square variation	f-Value	Result
1.	Types of Management	Between the groups	2	261.48	130.742	0.7148 (Table value = 19.33)	Not significant even at 5% level
		Within the groups	6	1097.41	182.901		
2.	Nature of Schools	Between the groups	2	1117.89	558.94	13.91 (Table value = 10.92)	Significant at 1% level
		Within the groups	6	241.00	40.167		

It can be inferred from the table that there is no significant difference in the availability and utilisation of physics laboratory facilities among the higher secondary schools in Thoothukudi education district with respect to the variable 'types of management' . But in the case of the variable 'nature of schools', there is significant difference in the availability and utilisation of physics laboratory facilities among the higher secondary schools in Thoothukudi educational district. From the mean scores, it is found that the availability and utilisation of physics laboratory facilities in higher secondary girls' schools is more than that of higher secondary boys' schools and co-education schools.

Discussions on Findings and their Educational Implications

(a) It is found that there is positive correlation between the availability and utilisation of physics laboratory facilities and students attitude towards physics practicals. It is, therefore, recommended that physics laboratories in the higher secondary schools should be equipped with all the necessary apparatus and the desired technical trained manpower. It should be made mandatory by the government.

(b) The attitude of girls, MPCB group students and local students at higher secondary levels is found to be more positive than boys, PCBZ group students and urban students respectively. This may be due to girls being more focused on their studies, the knowledge of basic mathematical relations gained by MPCB group students and more individual attention given in the rural schools due to number of students being small. So, it is recommended that special efforts should be made to motivate boys and PCBZ students and also to give them more exposure on mathematical relations pertaining to physics practicals. The availability of the instrument and apparatus is to be properly planned in urban schools so that each student does practical all by him herself.

(c) The study reveals that the higher secondary students in girls' schools and government schools have a more positive attitude towards practicals in physics than boys; and 'co-education schools' and 'aided and self-finance' schools respectively. This may be due to the fact that the girls' schools provide better opportunity to do more practials sometimes even organising special classes while the aided and self-financing schools are giving importance mainly to theory aspect. It is, therefore, recommended that it should be mandatory for all the schools to have all practicals done by their students. Continuous external assessment may be helpful in this regard.

(d) It is found that mother plays vital role in developing students' attitude towards practicals in physics. This needs to be further explored to relate it with specific reasons.

(e) It is mainly found out from this study that the availability and utilisation of physics laboratory facilities are more in girls' schools. Besides, their achievements and attitudes are also better. So, it is recommended that the facilities may be enhanced in all the schools so that attitude of the students towards physics practicals, in particular, and towards science, in general, would automatically be developed.

Suggestions for Further Research

(a) Similar research work may be conducted regarding the availability and utilisation of laboratory facilities in other disciplines like chemistry, zoology, botany etc.

(b) The studies may also be conducted in university departments and research centres to analyse the availability of laboratory facilities for conducting research at the National level.

(c) The studies may also be conducted to find out correlation, if any, between the availability and utilisation of science laboratory facilities and achievement in science practicals.

(d) A comparative study of students' achievement in science practical and achievement in science theory may also be undertaken.

Conclusion

If the physics laboratory is fully equipped and the facilities of the laboratory are utilised properly, students are likely to develop more positive attitude towards physics practicals and hence attain scientific attitude.

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Values and Laboratory Work in Science

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GENERALLY speaking, science is regarded as a value. free area of knowledge. But, as Talisayon (1990) holds, if left to itself science insinuates materialism and shere objectivity. Consequently, science conduces to values that tend to be foucused on material and sensate world to be backed by an impersonal way of thinking. There is a need to link science and ethical values or wider social consciousness.

Subsequent to the National Policy on Education (1986); Safaya (1986), Kishore (1990), Govinda (1993), Sheshadri (1992); have been emphassing value-orientation of education. In this light, value orientation of science instruction is a formidable challenge.

Scientific Facts and Values

Value education through science instruction is a combination of social ethics and science. According to Rabago (1990), science belongs to the realm of facts and values belong to the area of social responsibility. Doing and learning science takes place in a social setting with the question in focus — how the people or social group members should behave. Rabago further adds that it takes effort on the part of a science teacher to learn, improvise, develop and test methods for teaching values in the form of social responsibility and ethics.

According to Bloom et al (1971), valuing falls in the category of advanced educational objectives in the affective domain. Bloom's taxonemy of educational objectives in the affective domain consists of the following: (1) Receiving or attending (awareness, willingness to receive, be controlled or selected attention); (2) Responding (Acquiencscence in responding, willingness to respond, satisfaction in response); (3) Valuing (acceptance of a value, preference of a value, commitment; (4) Organisation (conceptualisation of a value system; (5) Characterisations by a value complex (generalised set, characterisation). Bloom had cautioned long ago that if affective educational objectives are not stressed values will slowly erode from practice.

Laboratory Work: Possibilities for Value Inculcation

Laboratory work in science provides ample opportunities to students for learning values. Students need to be made conscious about the value, review their laboratory work in terms of imbibed values and practice values deliberately during practicals. Rabago (1990) has described ten values that can be inculcated through laboratory work which have been summarised in Exhibit 1.

Exhibit-1

The Table Explaining Values During Laboratory Work

Value	Opportunity
1. Carefulness	• In doing experiments, i.e., while: - Planning the experience. - handling apparatus and equipment. - performing the experiment.
2. Objectivity	• In analysing data • In interpreting results
3. Perseverance	• In facing and explaining unexpected results • In facing the failure of equipment
4. Patience	• In waiting for results of experiments
5. Cleanliness	• On the working table • In the store-room
6. Orderliness	• In recording data • In placing equipment • In display of experimental set-up
7. Cooperation	• In willingness to work with others • In sharing materials
8. Honesty	• In gathering and reporting data or observation
9. Thrift	• In taking precaution and not wasting consumables
10. Neatness	• In preparing reports and their submission

In order to inculcate these ten values, these need to be shared with students of science. Deliberate efforts are required to be made both using the technique of self-evaluation peer-evaluation and teacher-evaluation to chart the progress of students in these values. The conscious effort is likely to result in values being internalised and becoming the part of the personalities of students.

Two Science-Related Value Education Methods

There are two common value education methods for science instruction. These are: (1) Value integration; and (2) Value clarification. In value integration, a science teacher does the following two things.

- Calling attention to the desirability of an identified value in the context of a scientific concept and its application in life.

- Showing wisdom in possessing it, i.e., the pros and cons of adhering to the identified value. Thus, the science teacher, while using the value integration method passes a judgement in respect of 'rightness' of a thing and contrasts it with the 'wrongness.'

On the other hand the *'Value Clarification Method'* formulated by Rath, Harmin and Siman (1976), is an elaborate method involving three processes, namely: (1) choosing, (2) prizing and (3) acting as shown in Exhibit 2.

Value clarification can become a powerful technique if used by science teachers for inclucating the laboratory-related values. If the group score on ten values as 'found by the teacher falls short of a criterion, a value-clarification-based group discussion can be held to find the causes for it and a resolve to meet the criterion.

Conclusion

To make a beginning in linking laboratory work and values, science teacher needs to share the ten identified values with students; prepare jointly with students group evaluation matrix; put in place a system of self evaluation, peer-evaluation and group-evaluation on values. Also, a quarterly value-clarification group discussion session on external evaluation using the value-evaluation matrix could be held for correction and re-practice.

Exhibit 2

The Table Illustrating the Three Steps of Value Clarification Method

Step	*Explanation*
1. Choosing	• Free choice from the given alternatives. • Thoughtful consideration of the consequences of each alternative before making a choice.
2. Prizing	• Cherishing the choice. • Affirming the choice publicity with logic.
3. Acting	• Exercising the choice consistently whenever an opportunity arises.

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I, P. Rajakumar, hereby declare that the particulars given above are true to the best of my knowledge and belief.

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